III. *A Collection of the* Electrical Expeririments *communicated to the* Royal Society *by* Wm. Watſon, *F. R. S. read at ſeveral Meetings between* October 29. 1747. *and* Jan. 21. *following.*

I.

An Account of the Experiments made by ſeveral Gentlemen of the Royal Society, *in order to diſcover whether or no the electrical Power, when the Conductors thereof were not ſupported by Electrics* per se *would be ſenſible at great Diſtances: With an Inquiry concerning the reſpective Velocities of* Electricity *and* Sound: *To which is added an Appendix, containing ſome further Inquiries into the Nature and Properties of* Electricity.

Read Oct. 29. 1747. IN the Paper I did myſelf the Honour ſome time ſince to communicate to the *Royal Society*, I took notice, that, among the many other ſurpriſing Properties of Electricity, none was more remarkable, than that the electrical Power, accumulated in any non-electric Matter contained in a glaſs Phial, deſcribed upon its Exploſion a Circuit through any Line of Subſtances non-electrical in a conſiderable Degree; if one End thereof was in Contact with the external Surface of this Phial, and the other End upon the Exploſion touched either the electrified Gun-barrel, to which the Phial in charging was uſually connected, or the iron Hook always fitted therein. This Circuit, where the non-electric Subſtances, which happen to be between the Outſide of the Phial and its Hook, conduct Electricity equally well, is always deſcribed in the ſhorteſt manner poſſible; but if they conduct differently, this Circuit is always formed through the beſt Conductor, how great ſoever its Length is, rather than through one which conducts not ſo well, though of much leſs Extent.

It has been found, that in proportion as Bodies are ſuſceptible of having Electricity excited in them by Friction, in that Proportion they are leſs fit to conduct it to other Bodies; in conſequence whereof, of all the Subſtances we are acquainted with, Metals conduct beſt the electrical Powers; for which Reaſon the Circuit before ſpoken of is formed through them the moſt readily. Water likewiſe is an admirable Conductor; for the electrical Power makes no Difference between Solids and Fluids as ſuch, but only as they are non-electric Matter.

In order to give an Idea of what is underſtood by this Circuit, we will mention an Example or two, from which all the other may naturally be deduced. If a Perſon ſtands upon a dry wooden Floor with a coated Phial ever ſo highly charged in one of his Hands, and if another Perſon, without touching the firſt, ſtands but ſix Inches from him, and touches the iron Hook of the Phial, neither of them are ſhocked; becauſe the Floor between them, tho' the Diſtance is ſo ſhort, will not conduct the Electricity ſufficiently quick. But if theſe two Perſons tread upon a Piece of Wire laid between them, they each of them feel the electrical Commotion in that Arm, which touches the Phial and Hook, and in that Foot which treads upon the Wire; the Wire here conducting the Electricity quick enough, which the dry Floor would not. The Circuit is here formed by the coated Phial, its Hook, ſo much of the Bodies of theſe two Perſons as formed a curve Line between the Wire, the Phial, and Hook, and the Wire between theſe Perſons. If theſe Perſons ſtand upon, or touch with any Part of their Bodies any Non-electrics, which readily conduct Electricity, the Circuit is completed, and the Effect is the ſame: And this is occaſion'd by the ſhort Space of Time, in which the loaded Phial is diſcharged, when any Matter of what kind ſoever readily conducting Electricity happens to be between the coated Phial and its Hook, and is ſo connected as to communicate with both upon the Diſcharge of the Phial.

Monſieur *le Monnier* the younger at *Paris*, in an Account tranſmitted to the *Royal Society*, takes notice of his feeling the Stroke of the electrified Phial along the Water of two of the Baſons of the *Thuilleries* (the Surface of one of which is about an Acre) by means of an iron Chain which lay upon the Ground, and was ſtretched round half their Circumference.

Upon theſe Conſiderations it was conjectured, as no Circuit had as yet been found large enough ſo to diſſipate the electrical Power as not to make it

perceptible,

perceptible, that if the non-electrical Conductors were properly diſpoſed, an Obſerver might be made ſenſible of the electrical Commotion quite acroſs the River *Thames*, by the Communication of no other Medium than the Water of that River. But as perhaps, in what relates to Electricity leſs than in any other Part of Natural Philoſophy, we ſhould draw Concluſions but from the Facts themſelves, it was determined to make the Experiment.

The making this Experiment drew on many others, and as the Gentlemen concerned flatter themſelves that they were made with ſome Degree of Attention and Accuracy, they thought it not improper to lay a Detail of all the Operations relating thereto, before the *Royal Society*.

In order to try whether or no the electrical Commotion would be perceptible acroſs the *Thames*, it was abſolutely neceſſary that a Line of non-electric Matter, equal in Length to the Breadth of the River, ſhould be laid over it ſo as to touch the Water thereof in no Part of its Length; and the Bridge at *Weſtminſter* was thought the moſt proper for that Purpoſe, where the Water from Shore to Shore was ſomewhat more than 400 Yards.

Accordingly on *Tueſday July* 14, 1747. to ſee the Succeſs and aſſiſt in making the Experiment, there met *Martin Folkes* Eſq; Preſident of the *Royal Society*, the Right Honourable the Earl *Stanhope*, *Richard Graham* Eſq; *Nicholas Mann* Eſq; and myſelf, with proper Perſons to execute what was required of them in the various Parts of theſe Experiments.

A Line of Wire was laid along the Bridge, not only through its whole Length, but likewiſe turning at the Abutments, reached down the ſtone Steps on each Side of the River low enough for an Obſerver to dip into the Water an iron Rod held in his Hand. One of the Company then ſtood upon the Steps of the *Weſtminſter* Shore holding this Wire in his left Hand, and an iron Rod touching the Water in his right: On the Steps facing the former upon the *Surry* Shore, another of the Company took hold of the Wire with his right Hand, and graſped with his left a large Phial almoſt filled with Filings of Iron, coated with Sheet-Lead, and highly electrified by a glaſs Globe properly diſpoſed in a neighbouring Houſe. A third Obſerver ſtanding near the ſecond dipped an iron Rod held in his left Hand into the Water, and touching the iron Hook of the charged Phial with a Finger of his right Hand, the Electricity ſnapped, and its Commotion was felt by all the three Obſervers, but much more by thoſe upon the *Surry* Shore. The third Obſerver here was no otherwiſe neceſſary, than that the River being full, the Iron was not long enough to be fixed in the Mud upon the Shore, and therefore was in want of ſome Support. The Experiment was repeated ſeveral times, and the electrical Commotion felt acroſs the River; but the Gentlemen preſent being much moleſted in their Operations by a great Concourſe of People, who many times broke the conducting Wire, and otherwiſe greatly incommoded them, and the Evening growing too dark for the Obſervers on different Sides of the Water to ſee each other, they were prevented from diverſifying the Experiments, as was intended, and only conſider'd theſe Trials as a ſtill further Encouragement for them to proſecute the Inquiry at a more favourable Opportunity.

Early therefore on *Saturday* Morning *July* 18, there met upon *Weſtminſter-Bridge* the *Preſident* of the *Royal Society*, the Right Honourable the Lord *Charles Cavendiſh*, *Richard Graham* Eſq; Dr. *Bevis*, and myſelf, with proper Aſſiſtants. At the preceding Meeting, the electrical Machine's being placed at ſome Diſtance from the Water being found inconvenient, the following Alteration was made in the Diſpoſition of the *Apparatus*.

A Room up two Pair of Stairs in a commodious Houſe neareſt the Bridge on the *Surry* Shore was provided, in which was placed the electrical Machine with the Gun-barrel ſuſpended in ſilk Lines. From this Room, on account of its Height, the Signals on both Sides of the River were eaſily obſervable. The coated Phial beforemention'd with its iron Hook was placed upon the Seat of the Window of this Room, and communicated with the Gun-barrel by the means of a Piece of iron Wire. One Extremity of another Wire was likewiſe fixed into the Bottom of the leaden Coating of the Phial, whoſe other Extremity reached therefrom over the Bridge to the Steps upon the *Weſtminſter* Shore, the Body of the Wire being placed as much as poſſible upon the Parapet of the Bridge. One or more Obſervers took each other by the Hand, the firſt of which muſt neceſſarily take the Wire in his left Hand, and the laſt, upon the proper Signal given, either dip his right Hand into the Water, or (which makes the Poſture more agreeable) a Rod of Metal held therein. Another Wire having no Communication with any of the former, was let down from the before-mention'd Room, and down the Steps upon the *Surry* Shore: One Extremity of this Wire was held in the Hand of an Obſerver ſtanding upon theſe Steps, who dipped an iron Rod held in his other Hand into the Water: To the other Extremity of this Wire was faſtened a ſhort iron Rod, with which, when the elecfied Phial was ſufficiently charged, and the Signal given, the Gun-barrel was to be touched.

The Gentlemen, by this Diſpoſition of the *Apparatus*, propoſed to examine principally theſe three Queſtions: Firſt, whether or no the Obſervers ſtanding on each Side of the River would perceive the electrical Commotion, each putting an iron Rod into the Water? Secondly, Whether or no the Obſervers on both Sides of the River would feel the electrical Commotion, when the Obſerver ſtanding upon the *Weſtminſter* Shore removed the iron Rod held in his Hand out of the Water? Thirdly, Whether or no the electrical Power was perceptible to the Obſervers on both Sides of the River, if the Obſerver upon the *Weſtminſter* Shore dipped his Hand into a Pail of Water, which had no Communication with the Water of the *Thames*.

It was determined firſt, upon proper Signals, to diſcharge the electrified Phial in the manner before-mention'd, the Obſervers on each Side of the River holding the iron Rods in the Water, and this Experiment was to be repeated three times. This was attempted accordingly; and although the Obſerver on the *Surry* Shore was each time ſmartly ſtruck, the *Preſident* of the *Royal Society*, who obſerved with the utmoſt Attention upon the *Weſtminſter* Shore, gave the Signal that he felt nothing. The Company was ſurpriſed at this Want of Succeſs in the Experiment; but, upon examining the Wire, which was laid over the Bridge, it was found to have been broken by ſome Accident, after it had paſſed over about a fourth Part of the Bridge. The Wire being refitted, it was agreed to make the ſame Experiment ſix times more: This was done accordingly, and the electrical Commotion was felt each time by the Obſervers on both Sides of the Water, but much ſmarter by thoſe on the *Surry* Side. It was then thought proper to repeat this Experiment three times more upon the Signal's being given: but, in making the firſt of theſe, the Obſerver in the Room with the Machine, diſcharged the electrified Phial, before the Obſerver upon the *Surry* Shore had dipped his iron Rod into the Water, and therefore no Effect was perceived by the Obſerver on the oppoſite Shore. The electrified Phial therefore was again diſcharged three other times, and the Commotion felt by the Obſervers on both Sides of the River.

To examine the ſecond Queſtion, no other Alteration was neceſſary in the whole *Apparatus*, than that the Obſerver upon the *Weſtminſter* Shore ſhould not dip either his Hand, or the iron Rod held therein in the laſt Experiments, into the Water of the River. The electrified Phial then was diſcharged three times without its Effects being in the leaſt perceiv'd by the Obſervers upon the *Weſtminſter* Shore; thoſe indeed on that of *Surry* felt the Shock as before.

In examining the third Queſtion, the *Apparatus* was in all other Reſpects the ſame as in the laſt; except that the Obſerver upon the *Weſtminſter* Shore had a Pail of Water placed upon a wooden Table, which ſtood upon the Stone Steps, and into which he was to put his right Hand upon the Signal's being given. This was accordingly done, and the electrified Phial being diſcharged three times, the electrical Commotion was felt as before by the Obſerver upon the *Surry* Shore; but not in the leaſt by him on the *Weſtminſter* Side, who held his Hand in the Pail of Water.

In all theſe Experiments, except in one before-mention'd, where the iron Rod was not in the Water, it was found, that whether the Obſervers on the *Weſtminſter* Shore, upon the Diſcharge of the electrified Phial, did or did not feel its Effects, they were always perceiv'd not only in the Arms of thoſe upon the *Surry* Shore, who formed a Line between the Extremity of the Wire there, and the Water of the River; but by any other Perſon, who ſtanding upon the Stone Steps, even where they were not wet, touched the Wire with his Hand. They were likewiſe felt by a Perſon upon the *Weſtminſter* Shore, ſtanding upon the wet Stone Steps, who did not form Part of the Line between the Extremity of the conducting Wire and the Water, otherwiſe than by touching the Wire with his Fingers.

As was before-mention'd, the Obſervers upon the *Weſtminſter* Shore did not feel the Effects of the diſcharged Phial near ſo ſtrong as thoſe on that of *Surry* in the firſt Set of theſe Experiments. When a Line was there form'd by the joining Hands of two or more Perſons, the firſt of which, on account

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of the Situation, held the conducting Wire in his left Hand, and the laſt touched the Water with an iron Rod held in his right, the Effects were moſt ſenſible in the left Arm of him who held the Wire: They were indeed manifeſtly felt by them all; but this Feeling was not great enough to be called a Shock, but, as was very properly expreſſed by one of the Company, it reſembled the Pulſation of a large Artery.

From the Examination of the firſt and ſecond Queſtions it appeared, that the Obſervers upon the *Weſtminſter* Shore were not ſenſible of the Effects of the Electricity, unleſs their Bodies deſcribed Part of the Circuit before ſpoken of; and this Circuit here conſiſted of Part of the Gun-barrel of the electrifying Machine, the Wire going from this Gun-barrel to the iron Hook, the Phial itſelf, the tail Wire of this coated Phial which reached therefrom acroſs the Bridge and down the Steps on the *Weſtminſter* Shore, the Line of Obſervers between this Wire and the iron Rod which dipp'd in the Water there, this iron Rod, a ſuppoſed Line of Water drawn quite acroſs the *Thames*, the Obſervers with their iron Rod on the *Surry* Shore, the iron Wire going from the right Hand of the laſt of theſe up into the Room where the electrifying Machine was placed, and the ſhort iron Rod to which one Extremity of this Wire was joined, and with which, in making the Exploſion, the Gun-barrel was touched. The Length of this Circuit, through which the Electricity was propagated was at leaſt 800 Yards, more than 400 Yards of which was formed by the Stream of the River.

From the Examination of the third Queſtion it appeared, that the electrical Commotion would not be felt from the Obſerver dipping his Hand in Water only, unleſs that Water was ſo diſpoſed as to become Part of the Circuit: and this Experiment was made, leſt the contrary might be ſurmiſed.

The Obſervers upon the *Weſtminſter* Shore not feeling the electrical Commotion equally ſtrong with thoſe of *Surry*, was judged to proceed from other Cauſes beſides that of Diſtance. For it muſt be conſider'd, that the conducting Wire was almoſt throughout its whole Length laid upon *Portland* Stone ſtanding in Water. This Stone, being in a great Degree non-electric, is of itſelf a Conductor of Electricity: And this Stone ſtanding in Water, no more of the Electricity was tranſmitted to the Obſervers on the *Weſtminſter* Shore than that Proportion, wherein Iron is more non-electric, and, conſequently, a better Conductor of Electricity than Stone. This was made more manifeſt, from obſerving that whether the conducting Wire upon the Bridge was broke or no, and, conſequently, whether the Obſervers upon the *Weſtminſter* Shore felt the electrical Commotion or no, not only the Obſervers upon the *Surry* Shore, who with their Wire form'd Part of the Line, felt the Shock in their Arms; but thoſe Perſons who only ſtood upon the Stone Steps there, and touched the Wire with their Fingers, felt the electrical Commotion in the Arm of that Hand which touched the Wire, and down their Legs. From whence, and from the Perſon before ſpoken of feeling the electrical Commotion ſtanding upon the wet Stone Steps of the *Weſtminſter* Shore, tho' not forming Part of the Line, but only touching the Wire with his Fingers, it was concluded, that, beſides the large Circuit before ſpoken of, there were formed ſeveral other ſubordinate Circuits between the ſame Steps of the *Surry* Shore, and the Bridge by means of the Water; whereby that Part of the electrical Power, felt by the Obſervers upon the *Surry* Side of the River, and not by thoſe on the *Weſtminſter* Side, was diſcharged.

Dr. *Bevis* having obſerved. and which was likewiſe tried here, that however well an electrified Phial was charged, its iron Hook would not fire the Vapours of warm Spirit of Wine held in a Spoon and applied thereto, if the Perſon who held the Phial, and he who held the Spoon did not take each other by the Hand, or have ſome other non-electrical Communication between them; it was therefore thought proper to try the Effects of Electricity upon ſome warm Spirit of Wine through the large Circuit before-mention'd. Accordingly the Obſervers being placed as before both upon the *Weſtminſter* and *Surry* Shores, no other Alteration was made in the before-mention'd *Apparatus*, than that the Wire which connected the Gun-barrel with the iron Hook of the coated Phial being laid aſide, the coated Phial itſelf was charged at the Gun-barrel, and then brought in the Hands of an Obſerver near the warm Spirits in the Spoon, which was placed upon the ſhort iron Rod before-mention'd, which was connected with the Wire which went to the Obſervers upon the *Surry* Shore. Upon preſenting properly the iron Hook of the charged Phial to the warm Spirit, it was inſtantly fired, and the electrical Commotion felt by the Obſervers on both Sides of the River.

It was then thought proper to try the Effects of the charged Phial upon the warm Spirit, when the

Wire was divided which was laid over the Bridge: Upon preſenting the iron Hook to the Spirit, a ſufficient Snap was given to the Spoon to fire the Spirit, but nothing ſo ſmart as in the former Experiment where the large Circuit was completed.

It was then tried, what the Effect would be upon the Spirit, if the charged Phial was diveſted of its long Wire which lay over the Bridge, and was only held in the Hand of an Obſerver; whilſt the Spoon with warm Spirit was placed in Contact of the iron Rod before mention'd, to which the Wire was connected, which went to the Obſervers upon the *Surry* Shore; and the Spirit was fired with much the ſame Degree of Smartneſs as in the laſt Experiment.

In theſe and all the ſubſequent Operations, Wires were made uſe of to conduct the Electricity preferable to Chains, as it before by great Numbers of Experiments had been fully proved, that whatever Difference there was in the Bulk of the Conductor, that is to ſay, whether it were a ſmall Wire, or a thick iron Bar, the electrical Strokes communicated thereby were equally ſtrong: And it had been further obſerved, beſides the Difficulty of procuring Chains of a requiſite Length for the preſent Purpoſes, that the Stroke at the Gun-barrel, when the Electricity was conducted by a Chain, was *cæteris paribus* not ſo ſtrong, as when that Power was conducted by a Wire. This was occaſion'd by the Junctures of the Links of the Chain not being ſufficiently cloſe, which cauſed the Electricity in its Paſſage to ſnap and flaſh at the Junctures, where there was the leaſt Separation; and theſe leſſer Snappings in the whole Length of the Chain leſſen'd the great one of the Gun-barrel.

Encouraged by the Succeſs of theſe Trials, the Gentlemen were deſirous of continuing their Inquiries, and of knowing whether or no the electrical Commotions were perceptible at a ſtill greater Diſtance. The *New River* near *Stoke-Newington* was thought moſt convenient for that Purpoſe; as at the Bottom of that Town, the Twinings of the River are ſo circumſtanced, that from a Place which we will call *A* to another *B*, the Diſtance by Land is about 800 Feet, but the Courſe of the River is near 2000. From *A* to another Place, which we will call *C*, in a right Line is 2800 Feet, but the Courſe of the Water is near 8000 Feet.

Accordingly, on *Friday July* 24. 1747 there met at *Stoke-Newington* the *Preſident* of the *Royal Society*, the Right Honourable the Lord *Charles Cavendiſh*, the Rev. Mr. *Birch*, *James Burrow* Eſq; *Peter Daval* Eſq; Mr. *George Graham*, *Wm. Jones* Eſq; *James Lever* Eſq; Mr. *Newcome*, *Charles Stanhope* Eſq; Mr. *Trembley* and myſelf, who were of the *Royal Society*, and Dr. *Bevis*. To this Gentleman the Company were much obliged, not only for his great Readineſs in aſſiſting in all the Operations, but likewiſe for the Uſe of his electrifying Machine, which from its Size was conveniently portable. This Machine was now placed in a Room up one Pair of Stairs in a Houſe near *A*, and the Signals from thence might eaſily be perceived by the Obſervers both at *B* and *C*.

It was propoſed, firſt to try the electrical Commotion by the ſame Obſervers as at *Weſtminſter-Bridge*, from *A* to *B*, the Diſtance as before-mention'd tion'd being about 800 Feet by Land, and 2000 by Water, in order if poſſible to determine the Difference of the Strength of the Electricity felt there, and at the Stone-Bridge at *Weſtminſter*; the Difference of the Length of the 2 Circuits being about 400 Feet in Favour of that of the new River.

To make the Experiment, an iron Wire was faſtened to the Coating of the glaſs Phial before-mention'd, and conducted from one of the Windows of the Room over the new River without touching the Water; and from thence to *B*, laying in its whole Length upon the Graſs in the Meadows, except where it paſſed over a Hedge. At *B*, when the Exploſion was to be made, one or more Obſervers were to take the Extremity of this Wire in one Hand, and touch the Water of the River as before with an iron Rod held in the other. Another Wire was let down from the other Window of the Room; one Extremity of which was joined to the ſhort iron Rod mention'd in the former Experiments, the other was held in the Hand of an Obſerver at *A*, whoſe other Hand held an iron Rod dipp'd into the River.

It was abſolutely neceſſary that theſe Wires ſhould touch each other in no Part of their Length, otherwiſe the before-mention'd Circuit would upon the Exploſion be completed from their firſt Contact.

When every thing was thus diſpoſed, and the Signals given, the charged Phial was exploded eight times, and the electrical Commotion every time ſmartly felt by the Obſervers both at *A* and *B*. Whether the Line of Obſervers at *B* conſiſted of one or more, they were always ſtruck, and that more ſharply than at *Weſtminſter Bridge* under the ſame Circumſtances. One of the Obſervers, taking the Wire in his Hand without having any Communication either with any of the other Gentlemen or the Water of the River, felt the Shock in his Feet.

It was then thought proper to make right Exploſions without any other Alteration in the *Apparatus* than that the Obſervers at *B*, ſhould ſtand in the Meadow at ſome Diſtance from the Water, without having any Communication therewith other than that furniſhed by the Ground. This was accordingly done, and the Stroke felt little if at all leſs than thoſe laſt-mention'd. But the electrical Strokes being felt ſmartly at the Diſtance of at leaſt 20 Feet from the Water occaſion'd a very perplexing Difficulty, as it was impoſſible by this Experiment to determine with any Certainty, whether or no the electrical Circuit was formed throughout the Windings of the River, or much ſhorter by the Ground of the Meadows. The Experiment plainly ſhewed that the Meadow-Ground with the Graſs thereon conducted the Electricity better than Stone; as it muſt be remember'd, that the Obſervers upon the Stone Steps upon the *Weſtminſter* Shore felt not in the leaſt degree the electrical Commotion, when their iron Rod was not in the Water, and themſelves ſtood upon the dry Stone Steps. But this Effect was ſuppoſed to be owing to the Meadow Ground here being encompaſſed on two Sides by the *New River*, and on the other by a wet Ditch, by both which it was generally well moiſten'd. To ſolve therefore this Difficulty a Series of Experiments were executed, of which hereafter.

The Gentlemen then determin'd to examine whether the electrical Commotions were perceptible from

Commotions were perceptible from *A* to *C*; a Diſtance not leſs than 2800 Feet by Land, and near 8000 by Water.

To execute this, to the former Wire, which was already conducted to *B*, another was added, which there croſſed the River without touching the Water; and reached almoſt to *C*, where the firſt of a Line of Gentlemen held as before the Wire in one Hand, and the laſt dipp'd the Iron into the Water. The Wire from the Machine to *A* was as before. Upon the Signal's being given, the charged Phial was exploded ten times, and its Effects plainly though but faintly perceived each time by ſome or other of the Obſervers, but never by them all. The electrical Commotion was always felt by that Obſerver, who held the Extremity of the Wire, but never by him who held the iron Rod in the Water. It was in one Experiment felt by the Obſerver who held the Wire, not felt by the next who held the Hand of the former, and yet plainly perceived by the third who joined the ſecond. Thoſe who did not themſelves feel the electrical Commotion here, did as at *B* ſee the involuntary Motions of thoſe who did. The Obſervers at *A* felt the Shocks in the ſame Degree, whether the other Obſervers were ſtation'd at *B* or *C*.

This Experiment further demonſtrates the Diſtance to which the electrical Power may be conveyed: but the ſame Difficulty occurs here as in the laſt; to wit, whether the Circuit was compleated by the Ground, or by the Water of the River?

Theſe ſame Operations, which ſhewed at how great a Diſtance the electrical Commotion was perceptible,

ceptible, ſolved likewiſe three Queſtions of a ſubordinate Nature.

Firſt, whether or no, *cæteris paribus*, any Difference occurred in the Succeſs of the Experiment, if the long Wire, inſtead of being joined to the Coating of the Phial, was faſten'd to the ſhort iron Rod, which upon touching the Gun-barrel occaſion'd the Exploſion; and if the ſhort Wire, which only went to the Obſerver at *A*, a Diſtance from the Machine not more than 30 Feet, was joined to the Coating of the Phial? Upon Trial no Difference * was found.

Secondly, Whether or no, *cæteris paribus*, any Difference in the electrical Commotion would be perceived, when that Power paſſes through the Arms of two Obſervers, whoſe Bodies made Part of the Circuit, ſtanding in the Room near the electrifying Machine; one of which takes the Extremity of the Wire that goes to the Obſerver at *A* in one Hand, and touches the Gun-barrel with the ſhort iron Rod held in his other Hand? The other Obſerver takes the Extremity of the Wire which goes to *B* or *C* in one Hand, and touches the Coating of the charged Phial with his other. In ſeveral Trials, where each of theſe Obſervers frequently changed Stations, no Difference in point of Strength was obſerved in the electrical Commotion.

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* No Difference is obſerved when the electrical Circuit is propagated through Subſtances which readily conduct Electricity; if they conduct it in a leſs Degree, the electrical Commotion is moſt perceptible to the Obſerver, who holds the Wire, which comes from the charged Phial.

Thirdly, Whether or no theſe two Obſervers laſt-mention'd received the Shock at the ſame time? They were ſeen to be both convulſed in the ſame Inſtant.

July 28. 1747, there met again at the ſame Place, to proceed further in theſe Inquiries, the *Preſident* of the *Royal Society*, the Right Honourable the Lord *Charles Cavendiſh*, the Reverend Mr. *Birch*, Sir *Francis Daſhwood* Baronet, *Peter Daval* Eſq; Mr. *Ellicott*, Mr. *George Graham*, *Richard Graham* Eſq; Mr. *Robins*, Mr. *Short*, Dr. *Wilbraham*, and myſelf, who were of the *Royal Society*, and Dr. *Bevis*.

The electrical Commotion was firſt tried from *A* to *B* before-mention'd, the iron Wire in its whole Length being ſupported, without any-where touching the Ground, by dry Sticks placed at proper Intervals of about three Feet in Height. The Obſervers both at *A* and *B* ſtood upon Originally-Electrics, and, upon the Signal, dipped their iron Rods into the Water. Upon diſcharging the Phial, which was ſeveral times done, they were both very much ſhocked, much more ſo than when the conducting Wires lay upon the Ground, and the Obſervers ſtood thereon, as in the former Experiments. The ſame Experiment was tried with the Obſerver at *A*, inſtead of the iron Rod, dipping a narrow Slab of *Portland* Stone into the Water of about three Feet and a half in Length; when the Shock was felt, but not ſo ſevere as through the iron Rod. This demonſtrated, as was before ſuggeſted, why the electrical Commotion was not felt ſtronger by the Obſervers upon the Weſtern Shore of the *Weſtminſter-*

Bridge; *viz.* that *Portland* Stone ſtanding in Water will conduct Electricity very conſiderably.

The Gentlemen then tried what would be the Effect, if the Obſerver at *B* ſtood upon a Cake of Wax holding the Wire as before, and touched the Ground of the Meadow with his iron Rod at leaſt 150 Feet from the Water; and if the Obſerver uſually placed near the River at *A*, had his Wire carried 150 Feet over the River as the former, ſtood upon an Originally-Electric, and touched the Ground with his iron Rod. Upon the Exploſion of the charged Phial, which was ſeveral times done, both the Obſervers were ſmartly ſtruck: This demonſtrated, that in theſe Inſtances the moiſt Ground of the Meadows made Part of the Circuit. The Obſervers were diſtant from each other about 500 Feet.

The Obſervers then, ſtation'd as in the laſt Experiment, ſtood upon the wax Cakes as before, without touching the Ground with the iron Rods, or any Part of their Bodies, and the charged Phial was exploded four times. Theſe were not at all felt by the Obſerver next to *B*, and without the greateſt Attention would not have been perceived by him next to *A*; and then only in ſome of the Trials, the Feeling of the Electricity was like that of a ſmall Pulſe between the Finger and Thumb of that Hand which held the Wire. The loaded Phial was again diſcharged four times more, without any other Alteration in the Diſpoſition of the *Apparatus* than that the Obſerver next to *B* ſtood upon the Ground; when the electrical Commotion was perceived by that Obſerver, though not ſo ſharp as when the other Obſerver at the ſame time ſtood upon the Ground. The Obſerver next to *A* felt the Tingling between his Finger and Thumb as before.

The Gentlemen were deſirous of trying the electrical Commotion at a ſtill greater Diſtance than any of the former through the Water, and where, at the ſame time by altering the Diſpoſition of the *Apparatus*, it might be tried, whether or no that Power would be perceptible through the dry Ground *only* at a conſiderable Diſtance. *Highbury* Barn beyound *Iſlington* was thought a convenient Place for this Purpoſe, as it was ſituated upon a Hill nearly in a Line, and almoſt equidiſtant from two Stations upon the *New River*, ſomewhat more than a Mile aſunder by Land, though following the Courſe of that River their Diſtance from each other was two Miles. The Hill between theſe Stations was of a gravelly Soil; which, from the late Continuance of hot Weather without Rain, was dry, full of Cracks, and conſequently was as proper to determine whether or no the Electricity would be conducted by dry Ground to any great Diſtance, as could be deſired. This hitherto had not been attempted; the Meadows in the Inſtances before quoted conducting the Electricity was ſuppoſed to be owing to the Moiſture of the Ground. The Streets of *London*, when very dry, had been found to conduct it ſtrongly about forty Yards, and the dry Road at *Newington* about the ſame Diſtance. Accordingly, on *Wedneſday*, *Aug.* 5. 1747. there met at *Highbury-Barn* the Right Honourable the Lord *Charles Cavendiſh*, the Reverend Mr. *Birch*, Mr. *George Graham*, *Richard Graham* Eſq; *N. Mann* Eſq; Mr. *Short*,

Short, *Daniel Wray* Eſq; and myſelf, who were of the *Royal Society*, and Dr. *Bevis*.

The electrifying Machine being placed up one Pair of the Stairs in the Houſe at *Highbury-Barn*, a Wire from the coated Phial was conducted upon dry Sticks as before to that Station by the Side of the *New River*, which was to the Northward of the Houſe. The Length of this Wire was 3 Furlongs and 6 Chains, or 2376 Feet. Another Wire faſten'd to the iron Bar, with which, in making the Exploſion, the Gun-barrel was touched, was conducted in like manner to the Station upon the *New River* to the Southward of the Houſe. The Length of this Wire was 4 Furlongs 5 Chains and 2 Poles, or 3003 Feet. The Length of both Wires, excluſive of their Turnings round the Sticks, was 1 Mile 1 Chain and 2 Poles, or 5379 Feet. For the more conveniently deſcribing the Experiments made here, we will call the Station to the Northward *D*, and the other *E*.

At this Diſtance the Gentlemen propoſed to try, firſt, Whether or no the electrical Commotion was perceptible, if both the Obſervers at *D* and *E*, ſupported by Originally-Electrics, touched the conducting Wire with one Hand, and the Water of the *New River* with an iron Rod held in the other? Secondly, Whether or no that Commotion was perceptible, if the Obſerver at *E*, being in all reſpects as before, the Obſerver at *D*, ſtanding upon Wax, took his Rod out of the Water? Thirdly, Whether or no that Commotion was perceptible to both Obſervers, if the Obſerver at *D* was placed upon Wax, and touched the Ground with his iron Rod in a dry gravelly Field at leaſt 300 Yards from the Water?

As from the Situation of the Ground, Trees, *&c.* neither of the Stations could be ſeen by each other, or by the Obſerver at the electrifying Machine, it was agreed to diſcharge a Gun as a Signal to get ready, and to do the ſame, as near as might be, half a Minute before each Exploſion.

In theſe Experiments, as well as the former, the coated Phial was each time charged as high as it could be; ſo that if the Difference of the Shock to the Obſervers was conſiderable, it was owing to other Cauſes more than to the Phial's being differently electrified.

To try the firſt Propoſition, eight Exploſions were made with the Obſervers at *D* and *E*, touching the Water, and ſtanding upon Wax, with their iron Rods in the Water. The firſt two of theſe were felt but weakly by the Obſerver at *D*; but in the other ſix he was ſtrongly ſhocked. The Obſerver at *E* felt nothing of the firſt ſix Exploſions; when, upon Examination, the Wire was found broken by ſome Accident; but this Obſerver was ſtrongly ſhocked by the two laſt. The Obſerver at *D* being ſhocked in four of theſe Exploſions, while in theſe four the Obſerver at *E* felt nothing, was owing to the Circuits being formed by the Ground between the Obſerver at *D* and the broken Wire. Upon account of the Wire's being broken, the Gentlemen tried three more Exploſions, when the Obſervers at both Stations felt the electrical Shock.

To try the ſecond Propoſition, four Exploſions were made with the Obſerver at *D* ſtanding upon an Originally-Electric, and taking his iron Rod out of the Water, the Obſerver at *E* as before. In each of theſe the Obſerver at *D* felt a ſmall Pulſation between his Finger and Thumb of that Hand, which held the Wire. The Obſerver at *E* felt each of theſe as ſtrong as before. This being different from the Obſervations made in the Experiments of the laſt Trials at our former Stations *A* and *B*, and many others; where *B* in the ſame Circumſtances with *E* here felt the electrical Commotion only in a ſlight Degree, was owing, as we were afterwards informed, to the impertinent Curioſity of the Servants of the Gentlemen, and other voluntary Obſervers, who, by touching the Wire which went from the coated Phial to the Obſerver at *D*, felt the Shock in their Arms and Ankles, and formed ſubordinate Circuits to *E*. The preventing theſe People from touching the Wires, was impoſſible; as great Part of them could be ſeen neither by the Obſervers at the Stations, nor by thoſe at the Houſe, and their being more than a Mile long.

The four other Exploſions were made without any other Alteration in the *Apparatus*, than that the Obſerver at *D* ſtood upon the Ground about four Yards from the Water without any Communication therewith. The Obſerver at *E* felt the Shocks in his Arms as before; but the Obſerver at *D* ſtanding upon the Ground was ſhocked in the Elbow and Wriſt of that Arm which held the Wire, and in both his Ankles.

To try the third Propoſition, eight Exploſions were made with the Obſerver at *D* ſtanding upon an Originally-Electric with his Rod in the Water of the River as before; but the Obſerver at *E* was placed in a dry gravelly Field about 300 Yards nearer the Machine than his laſt Station, and about 100 Yards diſtant from the River. He there ſtood upon the Wax, holding the conducting Wire in one Hand, and touched the Ground with an iron Rod held in the other. The Shock was each time felt by the Obſerver at *D*, but ſenſibly weaker than in the former Trials; but the Obſerver at *E* felt them all equally ſtrong with the former; the four firſt in his Arms, when he ſtood upon the Wax, and touched the Ground with his iron Rod; the other four in his Arm and Ankles, when he ſtood upon the Ground without the iron Rod.

In ſome of theſe Experiments, the Obſervers at *D* felt a Tingling as ſoon as they laid hold of the conducting Wire. This was conjectured to be owing to the Electricity, which conſtantly runs off while the coated Phial is filling, and preferably by the Wire, as the beſt Conductor.

From the Severity of the Shock, the Gentlemen, in ſome of theſe Trials, did not chooſe to have the Electricity paſs through their Bodies: But, as it was neceſſary for them to be ſenſible of the different Degrees of the electrical Commotions, they bound the conducting Wire round one of their Thumbs, and touched the iron Rod with the Fore-finger of the ſame Hand; when the electrical Commotion was felt only in ſo much of the Finger and Thumb of that Hand, as completed the Circuit.

By the Experiments of this Day, the Gentlemen were ſatisfied, that the dry gravelly Ground conducted the Electricity as ſtrongly as Water; which, though otherwiſe at firſt conjectured, they now found not to be neceſſary to convey that Power to great Diſtances; as well as that, from Difference of Diſtance only, the Force of the electrical Commotion was very little if at all impaired. They were convinced of the Truth of the firſt of theſe Facts, not only from both Obſervers feeling the electrical Commotion in the eight laſt Experiments, when the Obſerver at *E* was at ſuch a Diſtance from the Water, but alſo from the Obſerver at *D* feeling the Shock ſo ſtrong in four of the firſt ſix Exploſions, when the conducting Wire to *E* being broke at about 100 Yards Diſtance from the Houſe, that Obſerver felt nothing.

In this laſt Inſtance the Circuit was formed from the Phial by the Obſerver at *D* and his Wire, a Line of Ground which reached from the Station at *D* to the broken Wire that lay upon the Ground, and ſo much of this Wire as reached to the ſhort iron Rod, which touched the Gun-barrel in making the Exploſions. This induced the Gentlemen to conclude (as from many Experiments it was manifeſt, that when the intervening Subſtances conduct Electricity equally well, the Circuit was performed in the ſhorteſt manner poſſible), that when the Obſervers holding their iron Rods in the River at *D* and *E* were both ſhocked, the Electricity was not conveyed by the Water of the River, being two Miles in Length, but by Land, where the Diſtance was only one Mile; in which Space that Power muſt neceſſarily paſs over the *New River* twice, through ſeveral Gravel-Pits, and a large Stubble-Field. So that, admitting the Electricity did not follow the Tract of the River, the Circuit from *D* to *E* was at leaſt two Miles; *viz.* ſomewhat more than one Mile of Wire, which conducted the Electricity from the Houſe to the Stations, and another Mile of Ground, the ſhorteſt Diſtance between thoſe Stations. The ſame Inference was now drawn with regard to the Experiments at *A*, *B*, and *C*, in the *New River* before recited; *viz.* that as in all of them the Diſtance between the Obſervers was much greater by Water than by Land, the Electricity paſſed by Land from one Obſerver to the other, and not by Water.

From the Shocks which the Gentlemen received in their Bodies, when the electrical Power was conducted upon dry Sticks, they were of Opinion, that from Difference of Diſtance ſimply conſider'd, as far as they had yet experienced, the Force thereof was very little if at all impaired. When they ſtood upon Originally-Electrics, and touched the Water or Ground with an iron Rod, the electrical Commotion was always felt in their Arms and Wriſts: When they ſtood upon the Ground, and touched either the Water or Ground with their iron Rods, they felt the Shock in their Elbows, Wriſts, and Ankles: When they ſtood upon the Ground without the Rod, the Shock was always in the Elbow and Wriſt of that Hand, which held the conducting Wire, and in both Ankles. The Obſervers here being ſenſible of the electrical Commotion in different Parts of their Bodies, was owing in the firſt Inſtance to the Whole of its paſſing (becauſe the Obſerver ſtood upon Wax) through their Arms, and through the iron Rod: In the ſecond, when they ſtood upon the Ground, the Electricity paſſed both through their Legs, and thro' the Iron: In the third, when they ſtood upon the Ground without either Wax or Rod, the Electricity directed its Way through one Arm, and through both Legs to complete the Circuit.

The Gentlemen were deſirous of cloſing the preſent Inquiry, by examining not only whether or no the electrical Commotions were perceptible at double the Diſtance of the laſt Experiments in Ground perfectly dry, and where no Water was near; but alſo, if poſſible, to diſtinguiſh the reſpective Velocities of Electricity and Sound. To execute this, required the whole Sagacity and Addreſs of the Gentlemen concerned; for they had met with very great Difficulties in the laſt Day's Operations, where the Wire was conducted but little more than a Mile; all which could not but be greatly augmented by doubling that Diſtance; becauſe it was neceſſary, that the Houſe, wherein the electrifying Machine was placed, ſhould be viſible at leaſt at one of the Stations; and that the Space between that Houſe and the Stations, through which the Wire was conducted, ſhould be very little interſected by Hedges, Roads, or Foot-paths; neither ſhould the Wire in this Space be ſubject to be diſturbed by the Horſes or Cattle, which were grazing; nor ought it to touch in its Paſſage the Trees or any other Vegetables, which at this Seaſon of the Year were every-where luxuriant. To find a Place within a convenient Diſtance of *London* with theſe Requiſites was not very eaſy; but at laſt, *Shooters Hill* was pitched upon, as the moſt convenient.

As only one Shower of Rain had fallen during the preceding five Weeks, the Ground could not but be very dry; and as no Water was near, if the electrical Commotion was felt by the Obſervers at the Stations, it might be ſafely concluded, that Water had no Share in conducting it.

Auguſt 14. 1747. there met at *Shooters Hill* for this Purpoſe, the Rev. Mr. *Birch*, the Rev. Mr. Profeſſor *Bradley*, *Peter Daval* Eſq; Mr. *George Graham*, *R. Graham* Eſq; Mr. *Nourſe*, *George Lewis Scott* Eſq; Mr. *Short*, *Charles Stanhope* Eſq; and myſelf, who were of the *Royal Society*, and Dr. *Bevis*.

It was here determin'd (as the Gentlemen were ſatisfied from many of the former Trials, that if, when the coated Phial was diſcharged, the Obſervers at the Stations ſtood upon Originally-Electrics, and touched neither Water nor Ground with iron Rods, or any Part of their Bodies, the electrical Commotion would be ſcarcely perceptible) to make twelve Exploſions of the coated Phial, with an Obſerver placed at the ſeven Mile-Stone, and another at the nine Mile-Stone, both ſtanding upon Wax, and touching the Ground with an iron Rod. This Number of Exploſions was thought more neceſſary, as the Obſervers at theſe Stations were not only to examine whether or no the Electricity would be propagated to ſo great a Diſtance; but if were, the Obſerver at the ſeven Mile-Stone was by a ſecond Watch to take notice of the Time lapſed between feeling the electrical Commotion, and hearing the Report of a Gun fired near the Machine, as cloſe as might be to the Inſtant of making the

Exploſion: And therefore, to examine this Matter with the requiſite Exactneſs, this Number of Exploſions ſhould be made.

To execute this, the electrifying Machine was placed up one Pair of Stairs in a Houſe upon the Weſt Side of *Shooters Hill*; and a Wire from the ſhort iron Rod, with which the Gun-barrel was touched in making the Exploſions was conducted upon dry Sticks as before into a Field near the ſeven Mile-Stone. The Length of this Wire, excluſive of its Turnings round the Sticks, was a Mile, a Quarter and eight Poles, or 6732 Feet. In great Part of this Space it was found very difficult to ſupport the Wire, on account of our ſcarcely being able to fix the Sticks in the ſtrong Gravel there almoſt without any Cover of Soil; nor could the Wire in ſome Places be prevented from touching the Brambles and Buſhes, nor in one Field the ripe Barley.

Another Wire was likewiſe conducted upon Sticks from the coated Phial to the nine Mile-Stone. In this Space, the Soil being a ſtrong Clay, the Wire was very well ſecured, and in its whole Length did not touch the Buſhes. The Length of this Wire was 3868 Feet. As much as the Place, where the Obſervers were ſtation'd in a Corn-Field, was nearer the Machine than the ſeven Mile-Stone, ſo much were the other Obſervers placed beyond the nine Mile-Stone, that their Diſtance from each other might be two Miles. The forty Feet of Wire in theſe two Meaſures exceeding two Miles, was what connected the ſhort iron Rod before-mention'd, and the coated Phial, with their reſpective conducting Wires.

The Obſervers being placed at their reſpective Stations, the Obſerver at the Machine proceeded in making the Exploſions of the coated Phial; he having before placed an Aſſiſtant exactly in his View before the Window of the Houſe, who, upon the Word of Command, was to diſcharge a Musket. As ſoon as ever the Flaſh was ſeen to come from the Mouth of the Gun, the Obſerver diſcharged the electrified Phial. When eight Exploſions had been made, a Servant was ſent from the Gentlemen at the ſeven Mile-Stone giving an Account of the Wire's being broken, and the Sticks thrown down by a Man riding through them; that the Obſervers there had felt nothing; and deſired, as by this time the Wire was replaced, that we ſhould begin again. This was complied with, and twelve other Exploſions made without further Moleſtation.

Not only the firſt eight, but eleven of the laſt twelve very ſtrongly ſhocked the Obſervers at the nine Mile-Stone: At the twelfth Exploſion the Obſerver on purpoſe ſtood upon the Wax without touching the Ground with his iron Rod, or any Part of his Body; and only felt a ſlight Tingling in his Finger and Thumb that held the Wire. In another of theſe Experiments, as the Gentlemen here were ſatisfied in their own Perſons of the Strength of the electrical Commotion, they indulged two Country Fellows, who were By-ſtanders, with feeling one: Theſe two with four of the Gentlemen formed a Chain, the firſt of them taking hold of the Extremity of the Wire with one of his Hands. They all ſtood upon the Ground, and made no Uſe of the iron Rod. Upon the Exploſion they were all ſo ſtrongly ſhocked in their Arms and Ankles, that the Countrymen could by no means be prevailed upon to try the Experiment again. Why, in the firſt eight Exploſions, the Obſervers here were ſenſible of the electrical Commotion, when the Obſervers at the other Station felt nothing, was explained in the former Experiments. The Obſervers at this Station, from their Situation under the Hill, and from what Wind there was being againſt it, never heard the Report of the Gun.

Though the Obſervers near the ſeven Mile-Stone from the breaking of their Wire, were not ſenſible of the eight firſt Exploſions of the charged Phial, they felt the other twelve. This demonſtrated to the Satisfaction of the Gentlemen concerned, that the Circuit here formed by the Electricity was four Miles; *viz.* two Miles of Wire, and two Miles of Ground, the Space between the Extremities of that Wire. A Diſtance without Trial too great to be credited! How much further the electrical Commotion will be perceptible, future Obſervations can only determine.

The electrical Commotion by the Obſervers near the ſeven Mile-Stone was but ſlightly felt; nor could it be otherwiſe expected, the Wire in many Parts of its Length touching, as was before-mention'd, the moiſt Vegetables; which, in as many Places as they were touched, formed ſubordinate Circuits. We find, in all other Inſtances, that the whole Quantity of Electricity, accumulated in the coated Phial, is felt equally through the whole Circuit, when every Part thereof is in a great degree non-electric; ſo here the whole Quantity, or nearly ſo †, determined that Way, was felt by the Obſervers at the nine Mile-Stone; whilſt thoſe at the other Station felt ſo much of their Quantity only, as did not go through the Vegetables; that is, that Proportion only in which Iron is a greater Non-electric than the Vegetables.

Tho' the electrical Commotions, felt by the Obſervers near the ſeven Mile-Stone, were not ſtrong; they were equally concluſive in ſhewing the Difference between the reſpective Velocities of Electricity and Sound.

The Space through which Sound is propagated in a given Time, has been very differently eſtimated by the Authors, who have wrote concerning this Subject. *Roberval* gives it at the Rate of 560 Feet in a Second; *Gaſſendus*, at 1473; *Merſenne* at 1474; *Du Hamel*, in the Hiſtory of the *Academy of Sciences* at *Paris*, at 1172; the *Academy del Cimento*, at 1185; *Boyle* at 1200; *Roberts* at 1300; *Walker* at 1338; Sir *Iſaac Newton* at 968; Dr. *Derham*, in whoſe Meaſure Mr. *Flamſteed* and Dr. *Halley* acquieſced, at 1142. But by the Accounts ſince publiſhed by M. *Caſſini de Thury* in the Memoirs of the *Royal Academy* of *Sciences* at *Paris* for the Year 1738. where Cannon were fired at various as well as great Diſtances, under great Variety of Weather, Wind, and other Circumſtances, and where the Meaſures of the different Places had been ſettled with the utmoſt Exactneſs, Sound was propagated at a *Medium* at the Rate only of 1038 *French* Feet in a Second. The *French* Foot exceeds the *Engliſh* by ſeven Lines and a half, or is as 107 to 114: And conſequently 1038 *French* Feet are equal to 1106 *Engliſh* Feet. The Difference therefore of the Meaſures of Dr. *Derham* and M. *Caſſini* is $\frac{34 \textit{ French}}{36 \textit{ Engliſh}}$ Feet in a Second.[†] According to this laſt Meaſure, the Velocity of Sound, when the [*] Wind is ſtill, is ſettled at the Rate of a Mile, or 5280 *Engliſh* Feet in $4'' \frac{77}{100}$.

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† The Author of this Paper, from a great Variety of Experiments, is of Opinion; that in this and the like Diſpoſitions of the *Apparatus*, the electrical Power, accumulated in the Matter contained in the coated Phial, is directed upon the Exploſion thereof towards both Obſervers at the ſame Inſtant.

To return to our Purpoſe; the Length of the conducting Wire from the Machine to the Obſervers near the ſeven Mile-Stone was (as has been before-mention'd) a Mile, a Quarter, and 8 Poles, or 6732 Feet: The Length of that to the nine Mile-Stone, 3868 Feet. The firſt of theſe Meaſures only was made uſe of in the preſent Operations concerning the Velocity of Electricity. In twelve Diſcharges of the coated Phial, which were felt by Mr. *George Graham*, Mr. *Short*, and *Charles Stanhope* Eſq; the Obſervers near the ſeven Mile-Stone, and who, by a ſecond Watch of Mr. *Graham*'s, meaſured the

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[†] M. *Caſſini de Thury* afterwards meaſured the Velocity of Sound at *Aiguemortes* in *Languedoc*, and found the Obſervations there from thoſe made about *Paris* vary only half a Toiſe in a Second. See *Mem. de l' Acad. Royale des Sciences, pour l'année* 1739, *p.* 126.

[*] Dr. *Derham* found, that when Sound was carried againſt the Wind, not only its Diſtance but its Velocity was leſſen'd; and in M. *Caſſini*'s Memoir, there is an Experiment, where Sound being carried againſt the Wind, which then blew very ſtrong, was retarded near a twelfth Part of the uſual Time in its Progreſs.

Time between feeling the electrical Commotion, and hearing the Report of the Gun, with the utmoſt Attention and Exactneſs; the Time, I ſay, between feeling the electrical Commotion, and hearing the Report of the Gun, was, at a *Medium*, 5 Seconds and a Quarter, or $5''\frac{250}{1000}$. And as the Gun was diſtant from theſe Obſervers 6732 Feet, it follows, from the Experiments, which have been made on the Velocity of Sound, that the real Inſtant of the Diſcharge of the Gun preceded that of the Obſervers hearing its Report, at this time when the Strength of the Wind was not ſo great as to enter into the Computation, $6''\frac{087}{1000}$; or preceded the Inſtant when the electrical Commotion was felt only $0''.\frac{837}{1000}$. But this Inſtant was, from the Nature of the Experiment, neceſſarily prior to that of the electrical Exploſion, which was not made till the Fire of the Gun was actually ſeen; and therefore the Time between the making of that Exploſion, and its being actually felt by the Obſerver, which muſt have been leſs than $0''.\frac{837}{1000}$, was really ſo ſmall, as not to fall under any certain Obſervation, when it is to be diſtinguiſhed from that, which muſt of Neceſſity be loſt, between the Firing of the Gun, and the electrical Exploſion itſelf.

In all the Experiments, where the Circuit was formed to any conſiderable Length, though the coated Phial was very well charged, the Snap at the Gun-barrel, upon the Exploſion, was not near ſo loud as when the Circuit is formed in a Room; ſo that a By-ſtander, though verſed in theſe Operations, from ſeeing the Flaſh, and hearing the Report, would imagine the Stroke at the Ends of the conducting Wire to be very ſlight; the contrary whereof,

when

when the Wire has been properly conducted, has always happen'd.

From a Review of theſe Experiments, the following Obſervations may be deduced.

I. That, in all the preceding Operations, when the Wires have been properly conducted, the electrical Commotions from the charged Phial have been very conſiderable only, when the Obſervers at the Extremities of the Wire have touched ſome Subſtance readily conducting Electricity with ſome Part of their Bodies,

II. That the electrical Commotion is always felt moſt ſenſibly in thoſe Parts of the Bodies of the Obſervers, which are between the conducting Wires, and the neareſt and the moſt non-electric Subſtance; or in other Words, ſo much of their Bodies, as comes within the electrical Circuit.

III. That, upon theſe Conſiderations, we infer, that the electrical Power is conducted between theſe Obſervers by any non electric Subſtances, which happen to be ſituated between them, and contribute to form the electrical Circuit.

IV. That the electrical Commotion has been perceptible to two or more Obſervers at conſiderable Diſtances from each other, even as far as two Miles.

V. That when the Obſervers have been ſhocked at the End of two Miles of Wire, we infer, that the electrical Circuit is four Miles; *viz.* two Miles of Wire, and the Space of two Miles of the non-electric

Matter between the Obſervers, whether it be Water, Earth, or both.

VI. That the electrical Commotion is equally ſtrong, whether it is conducted by Water or dry Ground.

VII. That if the Wires, between the electrifying Machine and the Obſervers, are conducted upon dry Sticks, or other Subſtances non-electric in a ſlight Degree only, the Effects of the electrical Power are much greater than when the Wires in their Progreſs touch the Ground, moiſt Vegetables, or other Subſtances in a great Degree non-electric.

VIII. That by comparing the reſpective Velocities of Electricity and Sound; that of Electricity, in any of the Diſtances yet experienced, is nearly inſtantaneous.

I ſhall conclude this Paper with obſerving, that it was thought convenient to lay a Detail of all the Operations relating to theſe Experiments before the *Society*; in conſequence of which the Gentlemen may make themſelves Judges, how far the Deductions here recited are warrantable from the Experiments.

* The Gentlemen concerned were deſirous, if poſſible, of aſcertaining the abſolute Velocity of

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* Theſe Experiments to meaſure the abſolute Velocity of Electricity were made whilſt this Paper was at the Preſs, but as they had ſo near a Relation to the Experiments made the preceding Year, it was thought proper to inſert them here.

Electricity at a certain Diſtance; becauſe, although laſt Year, in meaſuring the reſpective Velocities of Electricity and Sound, the Time of its Progreſs was found to be very little, yet we were deſirous of knowing, ſmall as that Time was, whether it was meaſurable; and I had thought of a Method for this Purpoſe.

Accordingly, *Auguſt* 5. 1748. there met at *Shooter's Hill* for this Purpoſe the *Preſident* of the *Royal Society*, the Rev. Mr. *Birch*, the Rev. Mr. Profeſſor *Bradley*, *James Burrow* Eſq; Mr. *Ellicot*, Mr. *George Graham*, *Richard Graham* Eſq; the Rev. Mr. *Lawrie*, *Charles Stanhope* Eſq; and myſelf, who were of the *Royal Society*, Dr. *Bevis*, and Mr. *Griſchow* a Member of the *Royal Academy* of *Sciences* at *Berlin*.

It was agreed to make the electrical Circuit of two Miles, in the middle of which an Obſerver was to take in each Hand one of the Extremities of a Wire, which was a Mile in Length. Theſe Wires were to be ſo diſpoſed, that this Obſerver being placed upon the Floor of the Room near the electrifying Machine, the other Obſervers might be able in the ſame View to ſee the Exploſion of the charged Phial and the Obſerver holding the Wires, and might take notice of the Time lapſed between the diſchargeing the Phial and the convulſive Motions of the Arms of the Obſerver in conſequence thereof; inaſmuch as this Time would ſhew the Velocity of Electricity, through a Space equal to the Length of the Wire between the coated Phial and this Obſerver.

The electrifying Machine was placed in the ſame Houſe as it was laſt Year. We then found ourſelves greatly embarraſſed by the Wire's being conducted by the Side of the Road, which we were compell'd to, on account of the Space neceſſary for the meaſuring of Sound: But ſo great a Diſtance from the Machine was not now wanted, though the Circuit through the Wire was intended to be at leaſt two Miles. We had diſcover'd by our former Experiments, that the only Caution now neceſſary was, that the Wires conducted upon dry Sticks ſhould not touch the Ground, each other, or any Non-Electric in a conſiderable Degree in any Part of their Length: if they did not touch each other, the Returns of the Wire, be they ever ſo frequent, imported little, as the Wire had been found to conduct Electricity ſo much better than the Sticks. It was therefore thought proper to place theſe Sticks in a Field fifty Yards diſtant from the Machine. The Length of this Field being eleven Chains or 726 Feet, eight Returns of the Wire from the Top to the Bottom of the Field made ſomewhat more than a Mile, and ſixteen Returns more than two Miles, the Quantity of Wire intended for the Electricity to paſs through to make the Experiment.

We had found laſt Year, * that, upon diſcharging the electrified Phial, if two Obſervers made their Bodies Part of the Circuit, one of which graſped the leaden Coating of the Phial in one Hand, and held in his other one Extremity of the conducting Wire; and if the other Obſerver held the other Extremity of

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* *See* Page 66.

of the conducting Wire in one Hand, and took in his other the ſhort iron Rod with which the Exploſion was made; upon this Exploſion, I ſay, they were both ſhocked in the ſame Inſtant, which was that of the Exploſion of the Phial. If therefore an Obſerver, making his Body Part of the Circuit, was ſhocked in the Inſtant of the Exploſion of the charged Phial in the middle of the Wire, no Doubt would remain of the Velocity of Electricity being inſtantaneous through the Length of that whole Wire. But if, on the contrary, the Time between making the Exploſion, and ſeeing the Convulſions in the Arms of the Obſerver holding the conducting Wires, was great enough to be meaſured, we then ſhould be able to aſcertain its Velocity to the Diſtance equal to half the Quantity of Wire employed only, let the Manner of the Electricity's diſcharging itſelf be what it would.

It has been a Queſtion with ſome, who have conſider'd this Subject, whether the Electricity, in compleating the Circuit from the Matter contained in the Glaſs, paſſed, either by the Wire in the Mouth to the Coating of the Glaſs, the contrary Way by the Coating to the Wire in the Mouth, or otherwiſe directed itſelf both Ways at once? That the Electricity muſt paſs off one of theſe three Ways was certain, as the Exploſion would not be complete, unleſs in the Inſtant thereof ſome Matter very non-electric communicated between the Wire in the Mouth, and the Coating of the Glaſs. Unleſs therefore the Obſerver was placed in the Centre of the conducting Wires, it might be objected, that the Experiment was not made with the Exactneſs neceſſary; becauſe any Perſon, who was of Opinion, that the Electricity directed itſelf from the Mouth of the Glaſs to the Coating, might object, if the Wire from the ſhort iron Rod to the Obſerver was only half the Length of that between the Obſerver and the Coating of the Glaſs, that the Electricity, in the Time found, paſſed only through the ſhort Wire; and *vice verſa.* But if, as it was here thought proper, the Obſerver was placed in the Centre of the conducting Wire, let the Direction of the Electricity be what it would, no Difference could happen in the Reſult of the Experiments, if made with the neceſſary Caution; becauſe, if the Effects in the Middle and both Ends of the Wires were inſtantaneous, the Concluſion therefrom would be very obvious.

To make the Experiment, the ſame Phial filled with Filings of Iron, and coated with Sheet-Lead, which was uſed laſt Year, was placed in the Window of the Room near the Machine, and was connected to the prime Conductor by a Piece of Wire. To the Coating of this Phial a Wire was faſtened, which, being conducted upon dry Sticks to the before-mentioned Field, was carried in like manner to the Bottom, and being conducted thus from the Bottom of the Field to the Top, and from the Top to the Bottom ſeven other times, returned again into the Room, and was held in one Hand of an Obſerver near the Machine. From the other Hand of this Obſerver, another Wire of the ſame Length with the former was conducted in the ſame manner, and returned into the Room, and was faſten'd to the iron Rod with which the Exploſion was made. The whole Length of theſe Wires, allowing ten

Yards for their Tutns round the Sticks, amounted to two Miles a Quarter and ſix Chains, or 12276 Feet.

As the Night preceding theſe Experiments had been very rainy, Care was taken, by ſilk Lines properly diſpoſed, that the Wires in their Paſſage from the Window of the Houſe might not touch the Wood thereof; leſt, from the Moiſture of this Wood, the electrical Circuit might be ſhortened.

When all Parts of the *Apparatus* were properly diſpoſed, ſeveral Exploſions of the charged Phial were made; and it was invariably ſeen, that the Obſerver holding in each Hand one of the Extremities of theſe Wires was convulſed in both his Arms in the Inſtant of making the Exploſions.

Inſtead of one, four Men were then placed holding each other by the Hand near the Machine, the firſt of which held in his right Hand one Extremity of the Wire, and the laſt Man the other in his left. They were all ſeen convulſed in the Inſtant of the the Exploſion. Every one who felt it, complained of the Severity of the Shock.

It was then deſired by one of the Gentlemen concerned, that an Exploſion ſhould be made with the Obſerver holding only one of the Wires. This was done accordingly; but the Obſerver felt nothing, the Phial diſcharging itſelf in a different manner to what it did before, on account of the Circuit's not being completed.

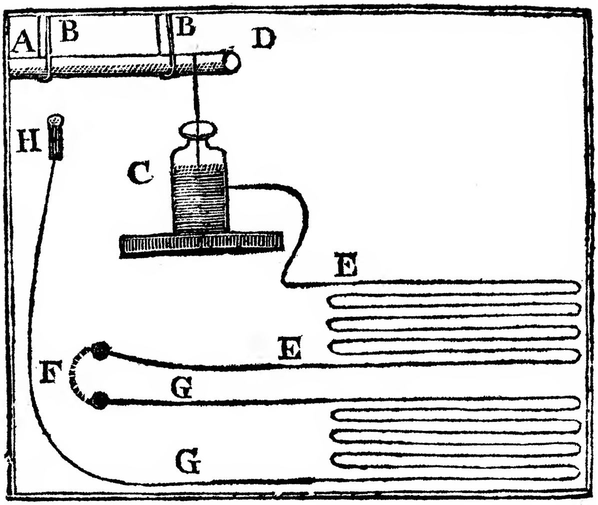
It was then tried, whether an Obſerver would be ſhocked upon the Diſcharge of the Phial, if the two Wires at their Extremities ſlightly touched each other, whilſt an Obſerver at the ſame time held one of theſe about a Foot from their Ends in each of his Hands? Upon Trial he felt nothing, though the

Phial exploded very quick, becauſe the iron Wire conducted the Electricity better than the Body of the Obſerver.

It was then tried, whether or no, as the Ground was wet, if the Exploſion was made with the Obſerver holding the Extremity of each Wire ſtanding upon the Ground near the Window of the Houſe, any Difference would ariſe in the Succeſs of the Experiment? No Difference was found, the Obſerver being ſhocked in the Inſtant of the Exploſion as before in both his Arms, and acroſs his Breaſt.

Upon theſe Conſiderations we were fully ſatisfied, that through the whole Length of this Wire, being as I mentioned before, twelve thouſand two hundred and ſeventy-ſix Feet, the Velocity of Electricity was inſtantaneous.

As it was found laſt Year, we obſerved again, that although the electrical Commotions were very ſevere to thoſe who held the Wires, the Report of the Exploſion at the prime Conductor was little, in compariſon of that which is heard when the Circuit is ſhort. From whence it was conjectured, that the very loud Report, in the Experiment of *Leyden* is confined to a very ſhort Circuit.



A, The prime Conductor.
B B, The ſilk Lines.
C, The coated Phial.
D, Its Hook communicating with the prime Conductor.
E E, The Wire reaching from the Coating of the Phial to the left Hand of the Obſerver, being more than a Mile in Length.
F, The Place of the Obſerver.
⌒, A ſuppoſed Line, drawn upon the Exploſion through his Body and Arms.
G G, Another Wire, of the Length of *EE*, which goes from the right Hand of the Obſerver to *H*.
H, The ſhort iron Rod to make the Exploſion.

2. *Some*

2. *Some further Inquiries into the Nature and Properties of* Electricity; *by* William Watſon *F. R. S.*

Read Jan. 21. 1747-8.

§ I. I PRESENTED to the *Royal Society October* 29. laſt a Paper containing ſome Accounts of what had been done by ſome Gentlemen of the *Society*, in order to examine, not only to what Diſtance the electrical Power was perceptible, but alſo to inveſtigate, as near as might be, the reſpective Velocities of Electricity and Sound: Electricity indeed is the Subject of the preſent Paper, yet, as it relates to *Phænomena* thereof different from thoſe mention'd in the former, I thought proper to ſeparate them.

§ II. I took notice, in my Sequel to the Experiments relating to Electricity *, of an Obſervation of the ingenious Profeſſor *Boſe* of *Wittemberg*, *viz.* 'that if the electrifying Machine is placed upon 'Originally-Electrics, the Man who rubs the Globe 'with his Hands, even under theſe apparently favourable Circumſtances, gives no Sign of being electrifed when touched by an unexcited Non-electric. 'But if another Perſon, ſtanding upon the Floor, 'does but touch the Globe in Motion with the End 'of one of his Fingers, or any other Non-electric, 'the Perſon rubbing is inſtantly electrifed, and that 'very ſtrongly.' This Experiment, almoſt a Year ſince, Dr. *Bevis* carried further, by placing whatever

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* Printed for *C. Davis*, *Lond.* 1746. *8vo.* p. 32.

ever Non-electric touched the Globe as a Conductor, whether it were a Man or a Gun-barrel, upon Originally-Electrics. If then, either the Man who rubbed the Globe, or he who only held his Finger near the Equator thereof, were touched by any Perſon ſtanding upon the Floor, a Snapping from either of them, I ſay, was perceptible upon that Touch.

§ III. As in my Sequel I had aſſerted, and by many Experiments therein had endeavoured to evince, that, contrary to the received Opinion, the Electricity was not derived from Glaſs, the Air, or other Electrics *per ſe*, I was deſired to conſider how far this Experiment did not prove the reverſe of that Aſſertion; inaſmuch as neither the Man who rubbed the Globe, or he who touched it with his Finger, from their being here both ſupported by Originally-Electrics, could receive any Supply from the Floor; and yet both of them ſnapped upon the Touch of a Perſon not ſupported by Electrics *per ſe*. Many Experiments had proved that the Electricity was not derived from the Glaſs; and therefore it was concluded, by Dr. *Bevis*, and ſeveral others to whom this Gentleman ſhewed the Experiment, that the Electricity here was communicated to the Perſon rubbing from the Air, by means either of the ſuſpended Gun-barrel, or of the Man who touched the Globe.

§ IV. I was by no means ſatisfied with this Concluſion, as being directly contrary to numberleſs Facts. From a careful Conſideration therefore of the Experiment itſelf, from comparing its Effects with thoſe of ſeveral others, and, in general, from ſurveying all the Properties of Electricity we are hitherto acquainted with, I gave the following as my Opinion.

1. That what we call Electricity is the Effect of a very ſubtil and elaſtic Fluid, diffuſed throughout all Bodies in Contact with the terraqueous Globe (thoſe Subſtances hitherto termed Electrics *per ſe* probably excepted), and every-where, in its natural State of the ſame Degree of Denſity.
2. That this Fluid manifeſts itſelf only, when Bodies capable of receiving more thereof than their natural Quantity are properly diſpoſed for that Purpoſe; and that then, by certain known Operations, its Effects ſhew themſelves by attracting and repelling light Subſtances, by a ſnapping Noiſe, Sparks of Fire, *&c.* directed towards other Bodies, having only their natural Quantity, or, at leaſt, a Quantity leſs than thoſe Bodies from which theſe Snappings, *&c.* proceed.
3. That no Snapping is obſerved in bringing any two Bodies near each other, in which the Electricity is of the ſame Denſity, but only in thoſe Bodies in which the Denſity of this Fluid is unequal.
4. That this Snapping is greater or leſs, in proportion to the different Denſities of the Electricity in Bodies brought near each other, and by which Snapping each of them becomes of the ſame Standard.
5. That Glaſs, and other Bodies, which we call Electrics *per ſe*, have the Property of taking this Fluid from one Body, and conveying it to another, and that in a Quantity ſufficient to be obvious to all our Senſes.
6. That, in the Experiment in Queſtion, the Reaſon why no Snapping is obſerved by a Perſon upon

on the Floor touching him who rubs the Globe with his Hands ſtanding upon Wax, without at the ſame time ſome other Non-electric ſupported by Originally-Electrics, or otherwiſe being in Contact with the Globe, is owing to whatever Part of this Man's natural Quantity of Electricity, taken from himſelf by the Globe in Motion, being reſtored to him again by the Globe in its Revolutions; there not being any other Non-electric near enough to communicate the Electricity to; and that therefore, in this Situation, the Electricity of this Man ſuffers no Diminution of its Denſity.

7. That the Fact is otherwiſe, when every thing elſe being as before, either a Gun-barrel ſuſpended in ſilk Lines, or a Man ſupported by Wax, or ſuch-like, is placed near the Globe in Motion; becauſe then, whatever Part of the Electricity of the Perſon rubbing is taken from him, is communicated either to the other Man or to the Gun-barrel, theſe, from their Situation, being the firſt Non-electrics, to which the Electricity taken from the Perſon rubbing can be communicated.

8. That, under theſe Circumſtances, as much Electricity as is taken from the Perſon rubbing, is given to the other; by which means the Electricity of the firſt Man is more rare than it naturally was, and that of the laſt more denſe.

9. That the Electricity in either of theſe Perſons is in a very different State of Denſity from what it naturally was, or from that of any Perſon ſtanding upon the Earth; this laſt being in a middle State between the two other Perſons; that is, he has not his Electricity ſo rare as the Man rub-

bing the Globe, nor ſo denſe as that of him ſupported by Electrics *per ſe*, and touching the Equator of the Globe.

10. That therefore the ſame Effect, a Snapping, is obſerved, upon bringing any Non-electric near either of theſe Perſons, from very different Cauſes: For it is apprehended, that, by bringing the Non-electric near him, whoſe Electricity is more rare, this Snapping reſtores to him what he had loſt; and that, by bringing it near him, whoſe Electricity is more denſe, it takes of his Surcharge, by which means their original Quantity is reſtored to each.

§ V. This Solution of this *Phænomenon*, without allowing any Part of the Electricity of either of theſe two Perſons to be furniſhed by the circumambient Air, was ſatisfactory, not only to the Gentleman who propoſed it, but to many of the *Royal Society*, excellent Judges of this Matter, to whom I ſhewed the Experiment: And this the more ſo, as it is to be obſerved, that if, under the before-mention'd Circumſtances, the Perſon rubbing the Globe was touched by him who held his Finger to the Globe, the Snapping was much greater than if either of them touched a Perſon ſtanding upon the Floor; as the Denſity of the Electricity between theſe two Perſons was ſo much more different than that of either of them to him on the Floor: Whereas did their Electricity proceed from the Air, from their being both electriſed they ought not to ſnap at all from their touching each other; or, admitting they did touch each other, they both of them, upon a Suppoſition that they did receive their Electricity alike from the Air, ſhould manifeſt the Accumulation thereof, and ſnap upon the Touch of a Man ſtanding upon the Floor, the contrary of which invariably happens.

§ VI. At this time I am the more particular concerning the Solution of this ſingular Appearance, as Mr. *Collinſon*, a worthy Member of this *Society*, has received a Paper concerning Electricity from an ingenious Gentleman, Mr. *Franklin*, a Friend of his in *Penſylvania*. This Paper, dated *June* 1. 1747. I very lately peruſed, by Favour of our moſt worthy *Preſident*. Among other curious Remarks there is a like Solution of this Fact; for though this Gentleman's Experiment was made with a Tube inſtead of a Globe, the Difference is no-ways material. As this Experiment was made, and the Solution thereof given upon the other Side of the *Atlantic Ocean* before this Gentleman could poſſibly be acquainted with our having obſerved the ſame Fact here, and as he ſeems very converſant in this Part of Natural Philoſophy, I take the Liberty of laying before you his own Words.

'1. A Perſon ſtanding on Wax, and rubbing a 'Tube, and another Perſon on Wax drawing the 'Fire; they will both of them, provided they do 'not ſtand ſo as to touch one another, appear to 'be electriſed to a Perſon ſtanding on the Floor; 'that is, he will perceive a Spark on approaching 'each of them with his Knuckle.

'2. But if the Perſons on Wax touch one ano'ther during the exciting of the Tube, neither of 'them will appear to be electriſed.

'3. If they touch one another after the exciting 'the Tube and drawing the Fire as aforeſaid, there 'will be a ſtronger Spark between them, than was 'between either of them and the Perſon on the 'Floor.

'4.

‘ 4. After ſuch a ſtrong Spark neither of them
‘ diſcover any Electricity.

‘ Theſe Appearances we attempt to account for
‘ thus:

‘ We ſuppoſe, as aforeſaid, that electrical Fire is
‘ a common Element, of which every one of
‘ theſe three Perſons has his equal Share before
‘ any Operation is begun with the Tube. *A*,
‘ who ſtands upon Wax, and rubs the Tube,
‘ collects the electrical Fire from himſelf into the
‘ Glaſs; and his Communication with the common
‘ Stock being cut off by the Wax, his Body
‘ is not again immediately ſupplied. *B*, who
‘ ſtands upon Wax likewiſe, paſſing his Knuckle
‘ along near the Tube, receives the Fire which
‘ was collected by the Glaſs from *A*; and his
‘ Communication with the common Stock being
‘ cut off, he retains the additional Quantity received.
‘ To *C* ſtanding on the Floor, both appear
‘ to be electriſed: For he, having only the
‘ middle Quantity of electrical Fire, receives a
‘ Spark upon approaching *B*, who has an over
‘ Quantity, but gives one to *A*, who has an under
‘ Quantity. If *A* and *B* approach to touch
‘ each other, the Spark is ſtronger; becauſe the
‘ Difference between them is greater. After ſuch
‘ Touch, there is no Spark between either of them
‘ and *C*, becauſe the electrical Fire in all is reduced
‘ to the original Equality. If they touch
‘ while electriſing, the Equality is never deſtroyed,
‘ the Fire only circulating. Hence have ariſen
‘ ſome new Terms among us. We ſay, *B* (and
‘ Bodies alike circumſtanced) is electriſed poſi-

‘ tively; *A*, negatively; or, rather, *B* is electriſed ‘ *plus*, *A*, *minus*. And we daily in our Experi‑ ‘ ments electriſe *plus* or *minus*, as we think pro‑ ‘ per. To electriſe *plus* or *minus*, no more needs ‘ be known than this; that the Parts of the Tube ‘ or Sphere that are rubbed, do in the Inſtant of ‘ the Friction attract the electrical Fire, and ‘ therefore take it from the Thing rubbing. The ‘ ſame Parts immediately, as the Friction upon ‘ them ceaſes, are diſpoſed to give the Fire, they ‘ have received, to any body that has leſs. Thus ‘ you may circulate it, as Mr. *Watſon* has ſhewn*; ‘ you may alſo accumulate or ſubſtract it upon or ‘ from any Body, as you connect that Body with the ‘ Rubber, or with the Receiver, the Communi‑ ‘ cation with the common Stock being cut off.’

The Solution of this Gentleman, in relation to this *Phænomenon*, ſo exactly correſponds with that which I offer'd very early laſt Spring, that I could not help communicating it.

§ VII. In Sect. 51. and 62. of my Sequel to the electrical Experiments, which I preſented to the *Royal Society* laſt Year, from not having conſider'd this Experiment in a ſtatical View, and from not then imagining the Velocity of Electricity ſo great as we ſince have found it, I concluded, that the Snapping obſerved, if a Perſon ſtanding upon the Floor touched the Man ſtanding upon Wax, who turned the Wheel of the electrifying Machine placed likewiſe upon Wax, to be owing to the Inverſion of the uſual Courſe of the Electricity; as that Snapping was only conſtant, when the Gun-barrel ſuſpended in ſilk Lines was touched by Non-electrics. As from divers Experiments I had found that Electricity was not furniſhed by dry Air, by many more that it could not come down clean ſilk Lines; and as, from his Snapping, the Man upon the Wax argued the Preſence of Electricity, I conceived that this could happen no other Way, than that the rubbing of the Globe by a Cuſhion or the Hand of a Man, gave it a Fitneſs to take off the Electricity, furniſhed by the ſuſpended Gun-barrel from the Non-electric upon the Floor, and lodge it upon the Machine, and upon the Man who turned the Wheel thereof. But the Experiment of circulating the electrical Fire *, where the Bruſh of blue Flame from a blunt Wire properly diſpoſed, can always be ſeen to paſs diverging into the Machine, though not ſo, when brought near the Gun-barrel under the moſt favourable Circumſtances; as well as the Experiment before-mention'd brought to ſhew that the Electricity came from the Air, have induced me to change my Opinion; and inſtead of the Courſe of the Electricity being inverted, the *Phænomena* aroſe, as far as I am capable of judging, from the Man who turned the Wheel of the electrifying Machine having leſs than his original Quantity of Electricity, and the Gun-barrel from having more: To theſe add, that the Perſon, who touched theſe while ſtanding upon the Floor, had a Quantity different from each of theſe, that is, his natural Quantity.

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* *See my* Sequel, *p.* 64.

I beg

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* See *Sequel* § 65.

§ VIII. I beg Leave to correct alſo what I mention'd in my *Sequel*, p. 69. in relation to my ſuggeſting, that, in the Exploſion of the charged Phial through the Body of a Man, or other Non-electrics, as much Electricity as was taken from his Body, was immediately replaced by the Floor of the Room upon which he ſtood: I having ſince found, that the charged Phial would explode with equal Violence, if the Hook of the Wire, which is uſually run through the Cork of the Phial, was bent in ſuch a manner as to come near the Coating of the Phial, without any other Non-electric being near, from which ſuch Quantity could be ſupplied.

§ IX. I take notice of theſe, inaſmuch as, notwithſtanding the very great Progreſs that has been made in our Improvements in this Part of Natural Philoſophy within theſe few Years, Poſterity will regard us only as in our Noviciate; and therefore it behoves us, as often as we can be juſtified therein by Experiment, to correct any Concluſions we may have drawn, if others yet more probable preſent themſelves.

§ X. I laid down and conſider'd largely in my Sequel *, that the Stroke from the Phial, in the Experiment of *Leyden*, was not in Proportion to the Quantity of Matter contained in the Glaſs, but was increaſed by the Quantity of Matter in the Glaſs, and the Number of Points of non-electrical Contact on the Outſide of the Glaſs. This Fact I have purſued further, and increaſed thereby the electrical Exploſion to an aſtoniſhing Degree. To this End I procured three cylindrical Phials blown very thin, about ſeventeen Inches in Height and four in Diameter: After theſe were coated within an Inch of their Necks with Sheet-Lead, I put into each fifty Pounds of leaden Shot. I choſe this Form for the Glaſſes, that the Matter therein contained might be expoſed under as large a Surface, as could conveniently be obtained. Theſe Glaſſes were placed near each other in a convenient Part of my Room, and did communicate with each other by means of a ſmall iron Rod lying upon all their Mouths, and touching Pieces of ſtrong Wire ſtuck into the Shot contained in them: By this Management one of theſe could not be electriſed without communicating with the reſt. The leaden Coatings of theſe Glaſſes were alſo connected together by ſmall Wires, all which center'd in one tail Wire; ſo that, when the Matter contained in theſe three Glaſſes was replete with Electricity, which was done by a Wire from the Gun-barrel faſtened to the iron Rod lying upon their Mouths, the whole Quantity of Electricity here accumulated might be diſcharged at once by touching the Gun-barrel with an iron Rod faſtened to the tail Wire. When the Glaſſes are ſufficiently electriſed, if the Room is dark, you will ſee Bruſhes of blue Flame from ſeveral Parts of the conducting Wire; and theſe indicate the proper Time of making the Exploſion. Theſe Glaſſes, from the Thinneſs of their Sides, and from the Weight of their leaden Shot, are very liable to burſt; and if one of them happens to have the leaſt Crack in any Part of its Surface, which is under the Lead, none of them can be electriſed; all the Electricity paſſing off by that Crack. The electrical Exploſion from two or three of theſe Glaſſes is not double or treble to that from one of them; but the Exploſion from three is much louder than that from two, that from two much louder than that from one.

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* See *p.* 11, 17, 19, *&c.*

§ XI. The Experiment juſt mentioned induced me to imagine, that the Exploſion from theſe Phials was owing to the great Quantity of non-electric Matter contained in them: And whilſt I was conſidering of ſome certain Method of aſſuring myſelf whether the Fact were ſo, Dr. *Bevis* informed me, that he had found the electrical Exploſion to be as great, as when he had accumulated the Electricity in a half Pint Phial of Water, by the following Method. He covered a thin Plate of Glaſs, of about a Foot ſquare on both Sides, with Leaf-Silver; this he made to adhere to the Glaſs with very thin Paſte. A Margin of an Inch was left on both Sides; otherwiſe, upon electrifying this Plate, the Electricity would be prevented from being accumulated upon one of its Surfaces, by being propagated from the Silver on one Side to that of the other. When the glaſs Plate was thus prepar'd, if it was placed upon a Table in ſuch a Manner, that, when fully electriſed by a Wire or ſuch-like from the prime Conductor, a Perſon touched the under Surface with a Finger of one of his Hands, and brought one of the Fingers of his other near the upper Surface thereof, or near the prime Conductor, he was ſhocked in both his Arms and acroſs his Breaſt. The ſame Effect happen'd, if, when this Plate was electrified in the before-mention'd Manner, a Perſon holding it in his Hand by the Margin, and without touching the Silver,

Silver preſented it, even ſome time after it had been taken from the prime Conductor, to another Perſon who touched the under Surface with his Finger, and held it there till he touched the upper Surface with a Finger of his other Hand.

§ XII. This Experiment was ſufficiently convincing, that the Greatneſs of the electrical Exploſion, in my former Trials, was not owing ſolely to the great Quantity of non-electric Matter contained in the Glaſſes; as the Exploſion from the glaſs Plate ſilvered was occaſioned by about ſix Grains of Silver, upon which the Electricity was accumulated; more eſpecially as this Exploſion was equal, if not ſuperior, to that from half a Pint of Water contained in a thin Glaſs as uſual, under the moſt favourable Circumſtances.

§ XIII. As each of the Surfaces of the glaſs Plate juſt mentioned meaſured ſixty-four ſquare Inches, I was deſirous of purſuing this Inquiry further; and accordingly procured a cylindrical glaſs Jar blown very thin, of ſixteen Inches in Height, and eighteen Inches in Circumference. This I cauſed to be covered both within and without with Leaf-Silver, to within an Inch of its Top. This Glaſs with its Margin made very clean (upon which the Succeſs of the Experiment conſiderably depends) was fully electrified by the means of a Piece of Chain, let down to the Bottom of the Jar, by a Wire from the prime Conductor; and the Exploſion made by its being placed upon a Plate of Metal, to which was faſten'd a Wire connected to an iron Rod, and this Rod was brought near ſome gilded Leather lying upon the prime Conductor. This Exploſion was equal to that from the three Glaſſes before-mention'd, containing a hundred and fifty Pounds of leaden Shot; though here the Weight of the Silver lining the internal Surface of the Glaſs, upon which the Electricity was accumulated, did not exceed thirty Grains. So much of the internal Surface of this Jar, as was covered with Silver, amounted, as the Surfaces of Cylinders are as their Length multiplied by their Periphery, and allowing thirty ſix ſquare Inches for the Bottom, to three hundred and ſix ſquare Inches. If this Exploſion was made in a dark Room, the Corruſcations within the Jar, at the Inſtant of the Exploſion, were extremely brilliant.

When this Jar is fully electrifed, if, inſtead of making it explode, you only bring the ſhort iron Rod, with which the Exploſion is uſually made, near a Piece of gilded Leather lying upon the prime Conductor, though not near enough to make the Glaſs explode at once, you hear the Electricity, accumulated within the Jar, eſcape with a Noiſe very like that of a ſmall heated iron Bar quenching in Water.

§ XIV. The great Exploſion from the Jar before-mention'd, when ſo little non-electric Matter was included therein, has cauſed me to be of Opinion, that the Effect of what we call the Experiment of *Leyden* is greatly increaſed, if not principally owing, not ſo much to the Quantity of non-electrical Matter contained in the Glaſs, as to the Number of Points of non-electrical Contact * within the Glaſs, and the Denſity † of the Matter conſtituting thoſe Points, provided this Matter be in its own Nature a ready Conductor of Electricity. For this Reaſon it is preſumed, that ſo much of the Lead contained in the Shot in the before-mention'd Experiment, only concurred to make the electrical Exploſion, as touched the internal Surface of

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* Bodies having the Power of readily conducting Electricity ſeems to depend very little upon their ſpecific Gravity ſimply conſidered: Metals, for Inſtance, and Water, are in a great Degree Non-electrics, and conſequently conduct Electricity the beſt of any Subſtances, that have yet fallen under our Notice; whereas the *Calces* of Metals, though very denſe Bodies, and very greatly more ſo than Water, prevent in a great Degree the quick Propagation of the electrical Power. So that a Phial coated within and without with Ceruſe, *i. e.* the *Calx* of Lead, and electriſed, did not, upon the Application as uſual of one Hand to the external Surface thereof, and touching the prime Conductor with the other, occaſion any Shock, or make any Exploſion more than the ſimple Stroke from the prime Conductor. The ſame Obſervation holds good with regard to red Lead, Litharge, and lunar Cauſtic or the *Calx* of Silver, none of which ſnap, when electriſed. For the ſame Reaſon, Filings of Iron, which are ruſty, *i. e.* have their Surfaces converted into a *Calx*, are much leſs proper to be put in Glaſſes to make the Experiment of *Leyden*, than thoſe that are not; inaſmuch as theſe laſt cauſe a much louder Exploſion than the firſt. The making uſe of ruſty Filings of Iron was the Occaſion of my mentioning in my *Sequel*, § XVI. that the Stroke from theſe was leſs than that from Water; the contrary of which I afterwards found true, when Filings of Iron not ruſty were ſubſtituted.

† I heretofore, *p.* 11, &c. of my *Sequel*, took notice, how much the Effect of this Experiment depended upon the Quantity of non-electric Contact upon the Outſide of the Glaſs.

of the Glaſs: As a great Part of this Surface was without Contact, occaſioned by ſuch of the Shot as preſented themſelves thereto, touching, from their ſpherical Figure, only in one Point, there conſequently remained without Contact comparatively great Spaces between each Shot. This Defect was obviated by the univerſal Contact of the Silver, and thereby was occaſion'd the greater Exploſion.

§ XV. The following Experiment has ſome Relation to the preceding. If a Phial of warm Water, without being coated with Sheet-Lead, or other non-electrical Matter, is electriſed by connecting it to the prime Conductor; and a Ring of ſmall Wire, in lieu of the uſual Coating, is put round this Phial, the Wire being continued of a ſufficient Length to touch the prime Conductor; upon diſcharging the Phial, you have a ſlight Exploſion, and a Flaſh of Fire ſeems at that Inſtant to fill the Glaſs. But if this Experiment is made in a very dark Room, and with great Attention, this Flaſh in the Phial will not then ſeem to proceed from the whole Quantity of Water contained therein; but, as far as the Suddenneſs of the Exploſion will permit the Eye to follow it, will be ſeen to occupy only the internal Surface of the Phial.

§ XVI. I order'd another glaſs Jar as large as poſſible to be blown, ſo that the Glaſs thereof might be very thin; and after many Attempts of the Glaſs-makers I procured one, the Height of which was twenty-two Inches, the Periphery forty-one. This was covered within and without, leaving a Margin of an Inch at Top, with Leaf-Braſs. As much of the internal Surface as was covered amounted to 1129 ſquare Inches. But the Difficulty I met with in procuring this Glaſs was ſufficiently recompenſed by the great Increaſe of the Exploſion therefrom, when fully electriſed, and diſcharged in the ſame manner as the glaſs Jar before-mention'd. The Report was vaſtly louder; all the attendant *Phænomena* greatly exceeded any thing of this kind I was before acquainted with. As the Quantity of Metal within this Jar did not exceed two Drams, this Experiment gives further Weight to my Opinion before-mention'd § XIV. in relation to the manner of increaſing the Effects of the Experiment of *Leyden*; and from what the *Phænomena* of that ſurpriſing Experiment principally proceed; *viz.* not from the Volume of the prime Conductor, nor from the Quantity of non-electrical Matter contained in the Glaſs, but from the Number of Points of non-electrical Contact both within and withoutſide of the Glaſs, and from the * Denſity of the Matter conſtituting thoſe Points.

§ XVII. It muſt be obſerved, that, *cæteris paribus*, the electrical Exploſion is greater from hot Water included in Glaſſes than from cold; and from theſe glaſs Jars warmed than when they are cold.

§ XVII.

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* Though the Denſity of the Matter conſtituting theſe Points proceeds from their Number in a mathematical Senſe, yet in a popular one I take the Liberty to diſtinguiſh them.

§ XVIII. The Exploſions from the large Glaſſes juſt mention'd fully electrified, as well as from ſmall ones under the ſame Circumſtances, will not be conſiderable, unleſs the Circuit, frequently mention'd in my Writings upon this Subject, be completed; that is, unleſs ſome Matter, non-electric in a conſiderable Degree, and in Contact with the Coatings of the Phials, is brought into Contact, or nearly ſo, with ſuch Non-electrics as communicate with the Matter contained in the Phials themſelves. When indeed the Circuit can be completed, the Exploſion from the large Glaſſes is prodigious; the whole Quantity of Electricity therein accumulated, or nearly ſo, being diſcharged in an Inſtant. But the Fact is otherwiſe, if the Circuit is not completed, and the iron Rod in the Mouth of one of theſe Phials is touched by a Non-electric (the Hand of a Man, for Inſtance) not in Contact with the tail Wire: For then there will be no Exploſion, no Shock; but the Perſon, approaching his Finger near the iron Rod, will ſee a Succeſſion of ſmall Sparks, more intenſely red than that large one ſeen, when the Phials explode at once; and the Perſon making the Experiment, will feel a very pungent Pain, but confined to that Finger which touches the iron Rod. This Succeſſion of Sparks continues, until the Electricity accumulated in the Phials is nearly exhauſted. So that the Exploſion from any given Quantity of Electricity, accumulated as before-mention'd, is greater or leſs in proportion to the Time expended in makeing that Exploſion: In like manner as a given Quantity of grained Gunpowder rammed, hard in a Piſtol, is almoſt inſtantaneouſly fired, and that with a great Report; when the ſame Quantity of Gunpowder rubbed fine, and rammed hard, takes a conſiderable Time in burning as a Squib, and makes no Exploſion.

§ XIX. The Cauſes why the charged Phial will not explode quick, without the Electricity therein deſcribing a Circuit through Subſtances non electric in a great Degree, may be very difficult to be aſſigned. It is ſufficient for us in the preſent Inquiry to be aſſured of its being a certain, an invariable Law: And in order to prove, that the Electricity, upon the Exploſion, paſſes with its whole Force through the Circuit of Non-electrics, contrary to what has been ſuggeſted, I made the following Experiment.

§ XX. I procured two ſmall ſquare iron Bars, of about fourteen Inches long: An Inch at each End of theſe I cauſed to be bent at right Angles. Theſe iron Bars were ſupported in ſuch manner (by Subſtances whether originally electric, or not, was noways material) that each of their Ends came within about two Tenths of an Inch of ſome warm Spirit of Wine, or Eſſence of Lemons in four Spoons placed upon a Table. I then ſuſpended a common coated Phial filled with Filings of Iron to the Gun barrel, the tail Wire of which reached to a Table at a few Feet Diſtance, and was placed under a braſs Weight which ſupported the Handle of the firſt of the Spoons: Over this Spoon, at the Diſtance juſt mention'd, I placed one of the ſquare iron Bars, and at its other End was placed another Spoon: This ſecond Spoon touched the Handle of the third, which was placed under one End of the other ſquare Bar, whoſe other End came near to the Spirit in the fourth Spoon, the Handle of which lay upon a Weight; and under this was placed a Wire connected to the ſhort iron Rod, with which the Exploſion was made, when the coated Phial was charged. When the Phial was well charged, if the Spirit of Wine ſent forth Vapours, and the ſquare iron Bars were at a proper Diſtance from it; upon making the Exploſion at the Gun-barrel the Electricity ſnapped between the Spirit and the iron Bars, and the Spirit was ſet on Fire at the ſame Inſtant in all the Spoons. It ſometimes happened, that ſome of them only were fired. If the iron Bars were too near the Spirit, it was not fired, though the Circuit was completed; becauſe then no electrical Flame ſnapped between the Rods and Spirit; that Effect happening only, when the Parts of the Non-electrics deſcribing the Circuit are not in immediate Contact; on the other hand, if the Space left between the Bars and Spirit was too great, the Circuit could not be completed, and there would be no Exploſion.

§ XXI. This Experiment will ſeem more ſurpriſing in the following manner. When the *Apparatus* is diſpoſed of as before, the tail Wire from the coated Phial, before it reaches to the Table, is faſten'd to an iron Rod ſtanding in a Pail of Water: Another iron Rod is likewiſe placed in the ſame Pail of Water, and a Wire from this laſt reaches under the Weight, which ſupports the firſt of the before-mention'd Spoons. From beneath the Weight which ſupports the Handle of the fourth Spoon, a Wire reaches to an iron Rod ſtanding in a ſecond Pail of Water, in which is placed alſo another iron Rod, to which is faſtened another Wire connected with the ſhort iron Rod, which is employed to make the Exploſion. When, with this Diſpoſition of the *Apparatus*, the charged Phial is cauſed to explode, the Spirit or Eſſence of Lemons in ſome or all of the Spoons is ſet on Fire; to accompliſh which, the Electricity muſt neceſſarily paſs through one of the Pails of Water, and poſſibly through both. But here it muſt be underſtood, that the Pails of Water ſtand upon a dry wooden Floor; for if they ſtand upon one that is wet, or upon the Ground, the Circuit will be, for Reaſons frequently mention'd in the Courſe of theſe Inquiries, completed between the two Pails, where the non-electric Matter is continuous, and be prevented from paſſing by the Spoons where it is not ſo; and this will defeat the Succeſs of the Experiment. The Number of Spoons in the Manner before-mention'd, and their Diſtance from each other, may be varied as far as is thought neceſſary. The Circuit may likewiſe be directed through any Number of Men, provided that each of them holds in one of his Hands a Spoonful of warm Spirit, and brings one of the Fingers of his other Hand at the proper Diſtance to the Spirit held in the Hand of the Perſon next him: By theſe means the Exploſion of the charged Phial will ſet on Fire the Spirit in ſeveral of the Spoons at the ſame time, provided the Perſons employ'd hold their Hands ſufficiently ſteady.

§ XXII. This Experiment exhibits new and unexpected *Phænomena:* In all the Experiments to kindle inflammable Subſtances by Electricity hitherto attempted both here and abroad, either the Spirit or the Non-electric, wherewith it was intended to be ſet on Fire, were placed upon Originally-Electrics. But here, on the contrary, although both one and the other are placed upon Non-electrics, we ſee the ſame Effect produced. Nor is the electrical Power leſſened, by exciting ſeveral different Quantities of Flame; in doing which, it paſſes ſo quick as to prevent the Poſſibility, in ſeveral Spoonfuls of Spirit, fired by the ſame Operation, of determining which of them was on Fire firſt: And though we know from its Effects, that the Electricity goes through the whole Circuit of Non-electrics with its whole Vigour, its Progreſs is ſo quick as not to affect, by by attracting or otherwiſe, light Subſtances diſpoſed very near the Non-electrics, through which it muſt neceſſarily paſs.

§ XXIII. I would here recommend to thoſe Gentlemen of the *Royal Society,* who laſt Summer meaſured the reſpective Velocities of Electricity and Sound, a Proceſs of this ſort to be executed at a proper Time; whereby they would be able to a very great Nicety to aſcertain the abſolute Velocity of Electricity. For it may be contrived, that a Man may be placed in the ſame Room with the electrifying Machine, taking hold of a Wire in each of his Hands:

Theſe Wires may be ſo managed, that by means of the electrical Circuit, the Man holding them may be made ſenſible of the electrical Commotion, even under the Eye of an Obſerver at the Machine; though before the Electricity can arrive at the Perſon holding the Wires, it will be obliged to paſs through whatever large Space ſhall be thought convenient for the Obſervation. The Time then ſpent tween the Exploſion of the charged Phial, and the Perſon holding the Wires feeling the electrical Commotion, will give the abſolute Velocity of Electricity to great Exactneſs *.

XXIV. As my Inquiries upon the Subject of Electricity have always tended as much as poſſible to the Analyſis thereof, I have often obſerved, that if, when the electrifying Machine ſtands upon the Floor, the Globes thereof are rubbed with their Cuſhions, or with Hands cover'd with Originally-Electrics of a ſufficient Thickneſs, and perfectly dry, no Electricity will be perceptible upon the Touch of a Gun-barrel ſuſpended in ſilk Lines, and touching the Globe in Motion, or upon the Touch of any other Subſtances ſupported by Electrics *per ſe*; or, in other Words, there will be no Accumulation of Electricity. The only Originally-Electrics fit for this Experiment (as all unctuous Subſtances, as Wax, Reſin, and ſuch-like, though Electrics *per ſe*, by ſticking to the Outſide of the Glaſs render it unfit to excite Electricity from other Bodies) are to be obtained from the Animal Kingdom: And of theſe only ſuch as do not partake, from their Manufacture or otherwiſe, of any non-electric Subſtances. Thoſe of this ſort, which I have tried, and always with the ſame Succeſs, when perfectly dry, have been Silk (woven or not), Velvet, Hair-Cloth, Woollen-Cloth, and the dry Skins of Rabbits dreſſed in their Fur; and the Event has been the ſame, whether theſe Subſtances have been rubbed under a greater or a leſs Degree of Friction: And ſcarce any Electricity has been perceptible, when thoſe Parts of theſe Subſtances, which immediately are in Contact with the Globes, have been rubbed over with dry Chalk, a non-electric Subſtance. But the Succeſs is different, when theſe originally-electric Subſtances have lain in damp Places, or have been held over the Steam of warm Water; becauſe then the Water imbibed by theſe Subſtances ſerves as a Canal of Communication to the Electricity between the Hands or Cuſhions and the Globes in the ſame manner, as the Air, replete with Vapours in damp Weather, prevents the Accumulation of Electricity in any conſiderable Degree, by conducting it as faſt as excited to the neareſt Non-electrics. On the contrary, moſt Subſtances of the Vegetable Kingdom, whoſe Form makes them fit for this Treatment, though made as dry as poſſible, furniſh Electricity, though in different Quantities. I have tried Hemp, Linen-Cloth of various Kinds, Paper both of Linen and Hemp, Cotton in the Wool, Fuſtian, Cotton-Velvet, and many others of this Claſs. I have covered at one time the Cuſhion, with which I rubbed a Globe, with eight Lamina of Sheet-Lead, and have excited Electricity from that Metal: And however improper a Deal-Board may ſeem for the Purpoſe of rubbing a Globe, I have more than once accumulated Electricity from that, though its Subſtance has the Appearance of being much leſs fit than every one of the Originally-Electrics I mention'd before.

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* This has been ſince put in Execution. *See above* p. 88.

§ XXV. To the Doctrine here laid down it may be objected, that Leather is an animal Subſtance, which, though perfectly dry, excites Electricity the ſtrongeſt of all the Subſtances hitherto diſcover'd; that dry Leather ought to be conſider'd as an Originally-Electric; and therefore, according to the Rule before-mention'd, ſhould not furniſh, from rubbing the Globe therewith, any Electricity at all. To this I anſwer, that though the dry Skins of Animals are Electrics *per ſe*, dry Leather is far from being ſo; and this is owing to the vaſt Quantities of reſtringent vegetable Subſtances imbibed by the Skins throughout their whole Contexture in the Operation of Tanning in ſome Species of Leather, and of ſaline Subſtances, ſuch as Alum, in others; both which Subſtances are non-electric, and of theſe Leather very conſiderably partakes: For by theſe the Hides and Skins of Animals (and any Muſcle of their Bodies is liable to the ſame Treatment), which otherwiſe are as putreſcent as any Part of their Bodies ſoever, are made to laſt through many Ages, and be ſubſervient to many valuable Purpoſes of Life. The ſame Concluſion muſt be drawn concerning Hats, which, tho' made of the Hair of Animals, furniſh Electricity, though but in a ſmall Degree: And this is occaſion'd by the mucilaginous and gummy Subſtances made uſe of by the Hatmakers, to give their Manufacture a ſuitable Stiffneſs.

§ XXVI. From what I have advanced § XI. XII. XIII. XIV. XV. XVII. it may poſſibly be conjectur'd, that the electrical *Effluvia* occupy only the Surfaces of Bodies electriſed; as we there found, that a very ſmall Quantity of Matter, diſtributed under a very large Surface, would occaſion a greater Accumulation of Electricity, than a very much more conſiderable Quantity of Matter under a leſs. But that the Electricity occupies the whole Maſſes of Bodies electriſed, and paſſes through their conſtituent Parts, is clearly demonſtrated by the following Experiments.

§ XXVII. When I firſt engaged in theſe Inquiries, to aſſure myſelf of this Fact, I enveloped an iron Rod about three Feet in Length with a Mixture of Wax and Reſin, leaving free from this Mixture only one Inch at each End. This Iron was warmed, when thus fitted, that the whole of its Surface, where it was intended, might be covered. This Rod, when electriſed at one of its Ends, ſnapped as ſtrongly at the other, as though it was without the Wax and Reſin. This could not have happened from the Electricity's paſſing along the Surface of the iron Rod, becauſe there it was prevented by the Originally-Electrics, and conſequently muſt of Neceſſity paſs through it.

§ XXVIII. A Phial of Water, in the Experiment of *Leyden* can be electriſed, and may be cauſed to explode, though the Wire, touching the Water in the Phial in making that Experiment, be run through a wax Stopple, exactly fitted to the Mouth of the Phial.

§ XXIX. I cauſed a glaſs Tube, open at each End, and about two Feet and a half long, to be capped with Braſs cemented to the Ends of the Tube. In the Centre of each of theſe Caps was faſtened a ſlender braſs Rod; and theſe were diſpoſed ſo in the Tube as to come within half an Inch of each other. When the Tube was properly ſuſpended in ſilk Lines with one of its Extremities near a glaſs Globe in Motion, the braſs Work at both Ends ſnapped equally ſtrong. As the Electricity could not paſs along the Surface of this Tube warmed and wiped clean, this Effect could not have happened, unleſs the Electricity pervaded the Subſtance of the braſs Caps. Upon touching the Braſs at the End of the Tube moſt remote from the electrifying Machine, the Snaps from one of the braſs Rods within the Tube to the other were ſeen to correſpond with the Snaps without. More Experiments of this kind might be added, but theſe, I preſume, are ſufficient to ſhew, that the Electricity occupies the whole Maſſes of non-electric Bodies electriſed. That the Electricity paſſes through Originally-Electrics to a certain Thickneſs I took notice of in a Paper I did myſelf the Honour to communicate in *February* 1745.

§ XXX. I ſhall forbear at preſent to lay before you a Series of Experiments *in vacuo*; from the Compariſon of which, with the Experiments in open Air it appears, that our Atmoſphere, when dry, is the Agent, whereby, with the Aſſiſtance of other Electrics *per ſe*, we are enabled to accumulate Electricity in and upon Non-electrics; that is, to communicate to them a greater Quantity of Electricity than they naturally have: From hence alſo we ſhall ſee, that, upon the Removal of the Air, the Electricity pervades the *Vacuum* to a conſiderable Diſtance, and manifeſts its Effects upon any Non-electrics, which terminate that *Vacuum*: And by theſe Means that originally-electric Bodies, even in their moſt perfect State, put on the Appearance of Non electrics, by becoming the Conductors of Electricity. But theſe Matters may poſſibly be the Subject of a future Communication.